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16. ABSTRACT

The purpose of this investigation was to determine the occurrence of selected microorganisms in the air in the vicinity of the O'Hare Water Reclamation Plant (OWRP), Des Plaines, Illinois. The contribution of the OWRP to ambient microbial aerosols was determined by comparing baseline, or preoperational, observations during fall and spring/summer months to those made after operation was initiated. Three sampling sites were positioned <150 m, 150 to 250 m, and >250 m downwind, while one location was upwind of the center of the two-stage activated sludge aeration tanks. Depending upon the wind direction, the first downwind site was frequently positioned at <5 m from the edge of the aeration tanks, with the other downwind sites proportionally nearer to this tank boundary. Aerosol concentrations of microorganisms, other than coliphages, were not significantly higher at and beyond the perimeter of the OWRP boundary (>250 m from the center of the aeration tanks) during plant operations than was observed in the baseline studies. This plant is a source of microbial aerosols within 250 m downwind of the center the aeration tanks and of coliphages at greater distances. Under the operating conditions present during this study, however, the probability of community exposure to bacterial aerosols, above that experienced before plant operations, is not significantly increased by the plant. Aerosols containing coliphages are, however, higher at or near the plant perimeter.

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STUDY OF MICROBIAL AEROSOLS EMITTED FROM A WATER RECLAMATION PLANT

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FOREWORD

The many benefits of our modern, developing, industrial society are accompanied by certain hazards. Careful assessment of the relative risk of existing and new man-made environmental hazards is necessary for the establishment of sound regulatory policy. These regulations serve to enhance the quality of our environment in order to promote the public health and welfare and the productive capacity of our Nation's population.

The complexities of envi ronmental problems originate in the deep interdependent relationships between the various physical and biological segments of man's natural and social world. Solutions to these environmental problems require an integrated program of research and development using input from a number of disciplines. The Health Effects Research Laboratory, Research Triangle Park, NC and Cincinnati, OH, conducts a coordinated environmental health research program in toxicology, epidemiology, and clinical studies using human volunteer subjects. Wide ranges of pollutants known or suspected to cause health problems are studied. The research focuses on air pollutants, water pollutants, toxic substances, hazardous wastes, pesticides, and nonionizing radiation. The laboratory participates in the development and revision of air and water quality criteria and health assessment documents on pollutants for which regulatory actions are being considered. Direct support to the regulatory function of the Agency is provided in the form of expert testimony and preparation of affidavits as well as expert advice to the Administrator to assure the adequacy of environmental regulatory decisions involving the protection of the health and welfare of all U.S. inhabitants.

This report provides information on the occurrence of microorganisms in air and in the vicinity of an activated sludge wastewater treatment plant before and after the plant became operational. Information on the levels of microorganisms in air near this type of facility may allow assessment of health effects and lead to development of measures, if necessary, to reduce exposure to potentially harmful materials.

F. Gordon Hueter, Ph.D
Director
Health Effects Research Laboratory

ABSTRACT

The purpose of this investigation was to determine the occurrence of selected microorganisms in the air in the vicinity of the O'Hare Water Reclamation Plant (OWRP), Des Plaines, Illinois. The contribution of the OWRP to ambient microbial aerosols was determined by comparing baseline, or pre-operational, observations during fall and spring/summer months to those made after operation was initiated. Three sampling sites were positioned < 150 m, 150 to 250 m, and > 250 m downwind, while one location was upwind of the center of the two-stage activated sludge aeration tanks. Depending upon the wind direction, the first downwind site was frequently positioned at < 5 m from the edge of the aeration tanks, with the other downwind sites proportionally nearer to this tank boundary.

Air sampling volumes were based upon predetermined sensitivity levels for each group of microorganisms. At each site, multistaged impactor and slit samplers were used to determine total aerobic bacteria-containing particle concentrations and particle size distributions. In addition, "large volume" air samplers, that included electrostatic precipitator and cyclone scrubber samplers, were used to detect aerosols of standard plate count organisms, total coliforms, fecal coliforms, fecal streptococci, Salmonella sp., other organisms within the total coliform group, coliphages of Escherichia coli C3000, and animal viruses detectable with Buffalo green monkey kidney (BGMK) and WI-38 cell cultures.

Low concentrations of several aerobic bacteria species and of certain coliphages were present in the air surrounding the newly constructed activated sludge plant before operation was initiated. After plant operations began at 21% to 67% of its design capacity of approximately 270,000 m^3/d [72 million gallons per day (MGD)], the frequency of detection of all microorganisms studied increased at the < 150 m downwind locations. The geometric mean total aerobic bacteria-containing particle (TABCP) concentrations, determined with slit samplers, increased from 59 to 218 colony forming units (cfu)/m^3 during the nighttime and from 34 to 57 cfu/m^3 during the daytime. The TABCP concentrations determined with Andersen samplers increased from 125 to 281 cfu/m^3 during the nighttime and from 87 to 234 cfu/m^3 during the daytime.

Using large volume scrubber (LVS) samplers at the first downwind location, standard plate count (SPC) organism geometric mean concentrations during the fall nighttime increased from 55 to 1325 cfu/m^3 and during the fall daytime from 49 to 220 cfu/m^3. Increases from 0.30 to 5.03 cfu/m^3 for total coliforms, 0.12 to 1.02 cfu/m^3 for fecal coliforms, 0.14 to 0.66 cfu/m^3 for fecal streptococcus organisms, and 0.004 to 0.095 most probable number plaque-forming units (mpnpfu)/m^3 for coliphages were also observed at this first downwind site after operations started. At 150 to 250 m downwind from the center of the aeration tanks aerosol concentrations of total coliforms, fecal coliforms, fecal streptococci, and coliphages were significantly higher during plant operations than before such operations started. When the aerosol concentrations of these organisms at the >250 m downwind site during plant operations were compared to preoperation concentrations, however, no significant ($p < 0.01$) differences could be detected from any group except for the coliphages.

Microbial aerosol concentrations were generally higher during the nighttime than during the daytime. The total coliform bacteria in aerosols during plant operations were predominantly *Enterobacter* sp., *Escherichia* sp., and *Klebsiella* sp., respectively. Animal viruses were detected at < 150 m downwind from the center of the aeration tanks in BGMK but not in WI-38 cells in two of twelve downwind air samples having total assay volumes of 385 to 428 m^3. Of the three virus isolates, two were identified as coxsackievirus B-1. The other virus was not identified by the antisera pools used.

The low-level concentrations of microbial aerosols observed before plant operations began did not increase beyond the perimeter of the plant on the east, south, and west sides during plant operations. Depending upon the meteorological and diurnal conditions, the concentration of certain microorganisms could occasionally increase beyond the north plant boundary. These concentrations, however, are very low (< 1 cfu or mpnpfu/m^3) and require very sensitive methods for detection.

This report was submitted in fulfillment of Grant No. R-806062 by IIT Research Institute and The Institute of Gas Technology under sponsorship of the U.S. Environmental Protection Agency. This report covers a period from July 24, 1978 to June 30, 1981, and work was completed as of October 31, 1981.

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SECTION 1

INTRODUCTION

Population growth within large urban regions necessitates expansion of existing wastewater treatment systems for processing increased volumes of sewage prior to utilization or discharge. Locating new wastewater treatment facilities in densely populated regions, however, requires consideration of the potential environmental and health effects of their operation. Microbial aerosols are emitted by wastewater treatment processes into the surrounding air (Hickey and Reist, 1975). Activated sludge treatment, for example, generates small bubbles by diffused air aeration that adsorb and concentrate suspended bacteria and viruses as they rise through the sewage depth in the aeration tank to the surface boundary. At this boundary, a surface film containing microorganisms is disrupted as these rising bubbles burst, releasing tiny aerosol droplets containing the bubble-adsorbed, as well as the surface film-associated microorganisms (Woodcock, 1955; Blanchard and Syzdek, 1970; Baylor, et al. 1977).

The nearly instantaneous evaporation which may occur as these droplets become suspended in air leaves dried residues referred to as droplet nuclei (Riley, 1974) that are subject to downwind dispersion. The survival and dispersion of the organisms that may be associated with these droplet nuclei are affected by organism characteristics and environmental factors such as relative humidity, temperature, irradiation, wind velocity, atmospheric stability, and atmospheric pollutants.

While processes of wastewater treatment have been shown to generate microbial-laden aerosols that can be carried downwind, the occurrence of potentially infectious microbial aerosols per se does not provide evidence of associated health risks. No conclusive evidence is yet available that demonstrates that persons residing in the vicinity of wastewater treatment facilities are subjected to greater health risks than those who do not dwell in such areas. Placing such facilities in regions of high population densities has, however, initiated concerns regarding the health implication of exposure to microorganism-containing wastewater aerosols (Metro. San. Dist. Greater Chicago, 1975).

One such facility, the O'Hare Water Reclamation Plant (OWRP), located in the City of Des Plaines, Illinois, was constructed to be operated as part of the regional Metropolitan Sanitary District of Greater Chicago (MSDGC) system. The proximity of this plant to a residential area has been the subject of concern over the past several years because of the potential for exposure to plant-emitted microbial aerosols. Because no data were available to determine the potential for community exposure to microbial aerosols that might be emitted from this plant, this study was initiated to determine the probability of such exposure over a wide range of environmental and meteorological conditions.

The probability of community exposure was evaluated by comparing the preoperational, or baseline, plant site microbial aerosol contribution to the surrounding environment to that observed after initiation of plant operations. This study was intended to provide data on whether or not significant increases in microbial aerosols could be attributed to facility operations during different seasons and atmospheric conditions.

SECTION 2

CONCLUSIONS

1. When operating at 21% to 67% of its design capacity, the O'Hare Water Reclamation Plant is a source of aerosols containing bacteria and viruses.

2. Significant aerosol concentration increases over the baseline at < 150 m downwind from the center (or, depending on the wind direction, to within 5 m from the edge) of the aeration tanks, were observed for total aerobic bacteria-containing particles, standard plate count organisms, total coliforms, fecal coliforms, fecal streptococci, and coliphages. The total coliform aerosols identified were predominantly *Enterobacter* sp., *Escherichia* sp., and *Klebsiella* sp. Animal viruses from assay volumes ranging from 385 to 428 m^3 in two cell culture lines were detected in two of twelve downwind air samples. Of three virus isolates, two were identified as coxsackievirus B-1 and the third was not identified with the antisera pool used.

3. At 150 to 250 m downwind from the center of the aeration tanks, no significant increases in microbial aerosol concentrations were observed during the daytime after the plant began operations. When considering both day- and nighttime samples, however, significant increases were observed for total coliforms, fecal coliforms, fecal streptococci, and coliphages. The concentrations of these organisms at 150 to 250 m downwind sites decreased substantially from those observed at the < 150 m downwind locations during plant operations. These concentrations decreased by 85% (5.0 to 0.77 cfu/m^3) for total coliforms, by 76% (1.02 to 0.24 cfu/m^3) for fecal coliforms, by 33% (0.66 to 0.44 cfu/m^3) for fecal streptococci, and by 68% (0.004 to 0.002 mpnpfu/m^3) for coliphages.

4. Aerosol concentrations did not significantly increase after the plant began operations for any bacteria studied at sampling distances beyond 250 m downwind from the center of the aeration tanks. The frequency of detection did, however, increase from 38 to 79% for total coliforms, from 0 to 63% for fecal coliforms, and from 69 to 89% for fecal streptococci. Coliphage concentrations were, however, significantly higher and their frequency of detection increased from 22 to 86% after the plant began operations.

5. Bacteria aerosol concentrations were directly related to sewage flow rate within 150 m downwind of the center of the aeration tanks during the fall season of plant operations, but, at downwind locations greater than 150 m downwind, inverse correlations were observed at night.

6. During plant operations, bacteria aerosol concentration was directly related to wind velocity during the spring/summer season at locations $\leq$ 250 m downwind of the center of the aeration tanks. Before operations, negative correlations were found at upwind and 150 to 250 m downwind locations.

7. Bacteria aerosol concentrations were directly related to temperature at locations within 150 m downwind of the aeration tanks during plant operations. At nighttime, however, negative correlations were observed at locations >250 m downwind and upwind.

8. Bacteria aerosol concentrations were generally inversely related to relative humidity.

9. Fecal streptococci and coliphages appear to be more stable in aerosols than the other indicator bacteria studied.

10. Low-level concentrations of bacteria and coliphages were present in the air in the vicinity of the OWRP before the plant began operations. These concentrations did not increase beyond the perimeter of the plant on the east, south, and west sides during plant operations. Depending upon the meteorological and diurnal conditions, the concentration of certain microorganisms could occasionally increase beyond the north plant boundary. These concentrations, however, are low (< 1 cfu or mpnpfu/m^3), and require very sensitive methods for detection.

SECTION 3

RECOMMENDATIONS

1. Selected microbial aerosol parameters should be monitored at the OWRP boundary during the nighttime when the plant begins operation at full capacity. These data should then be compared to the baseline observations made in this study to determine whether significant concentration increases occur at higher sewage flow rates.

2. Coliphages and fecal streptococci appear to be stable as aerosols and are recommended as indicators of potential sewage-borne aerosol contamination.

SECTION 4

METHODS AND PROCEDURES

STUDY SITE SELECTION

The site selected for study, shown in Figure 1, was the newly constructed O'Hare Water Reclamation Plant (OWRP) of the Metropolitan Sanitary District of Greater Chicago, located in Northwest Cook County in the City of Des Plaines in close proximity to the O'Hare International Airport. The OWRP was designed as a 272520 m^3/d (72 mgd) municipal sewage capacity two-stage activated sludge process plant, with the first stage achieving BOD removal and the second stage achieving NH_4-N removal. The dimensions of the two-stage aeration tank batteries, including walkways, was about 160 m by 200 m. This plant is bounded on the west by Elmhurst Road, north by Oakton Road, east by Marshall Road, and south by Willie Road. A large residential area is located north of Oakton Road, a light industrial region is east of Marshall Road, a commercial and light industry region is west of Elmhurst, and the north-west tollway is south of Willie Road. South of this tollway is located an area containing residential mobile homes.

Specific sampling sites were located at varying distances downwind or upwind of the center of the aeration tanks. This center was positioned approximately 80 m from the north and south aeration tank boundaries and about 100 m from the east boundary of the first stage aeration tank and about 100 m from the west boundary of the second stage aeration tank. This location was also about 120 m from the northwest and southwest corners of the second stage aeration tanks and about the same distance from the northeast and southeast corners of the first stage aeration tanks. As shown in Figure 1, the sites in closest proximity to the aeration tanks were located $<$ 150 m downwind from the center of the tanks. Since the exact location of these sites was determined by physical accessibility, many samples were taken near or at the aeration tank boundary. The 150 to 250 m downwind sampling locations were generally positioned on the plant property and, when positioned on the east or west side of the aeration tanks, these locations were situated in very close proximity to the settling tanks. The $>$ 250 m downwind location was beyond the immediate plant boundary when positioned to the north, south, and east. When positioned in a westerly direction, however, this site was located on the plant premises. The upwind location was positioned in an area that was also generally beyond 250 m from the center of the aeration tanks. It should be noted that, when this site was positioned in the northwest corner of the plant, it was frequently downwind from the pumping station.

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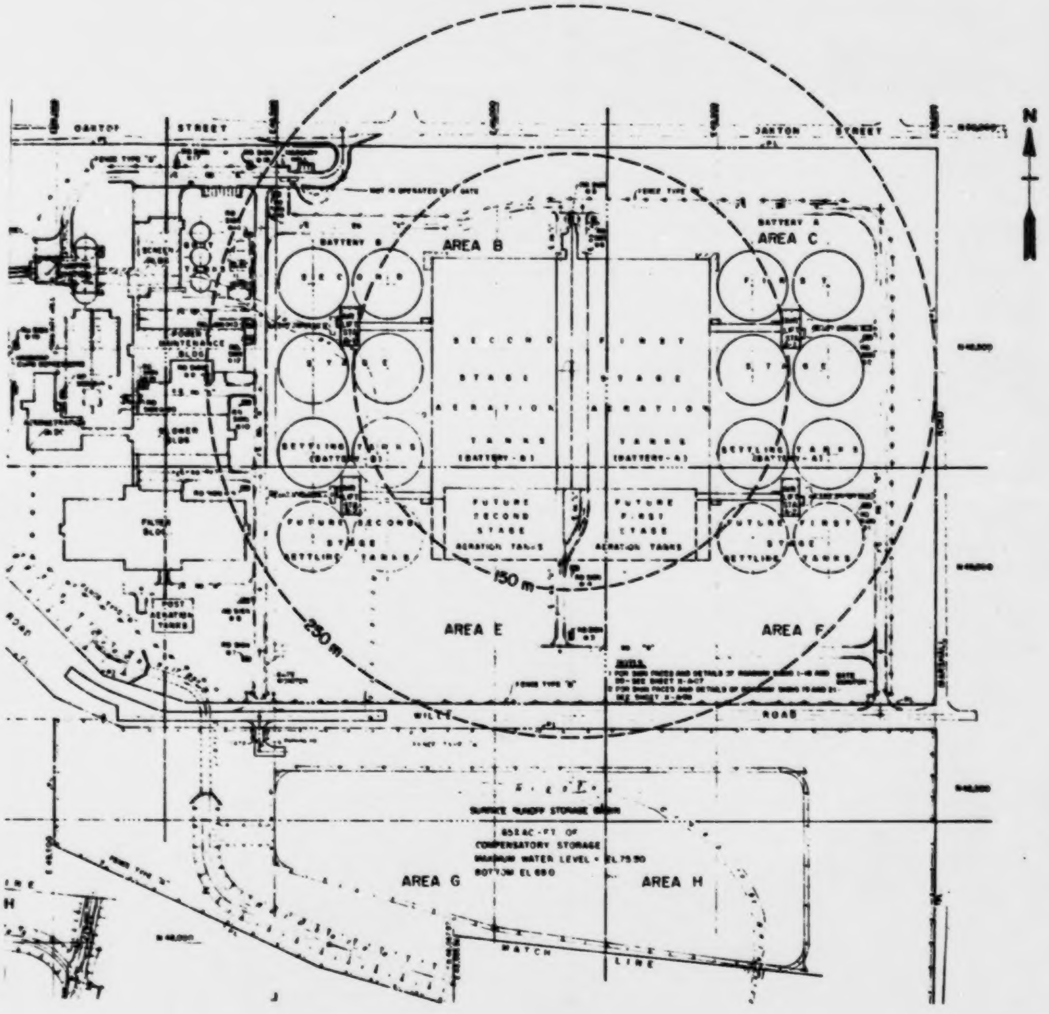
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COMPENSATORY STORAGE
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Figure 1. Schematic of O'Hare Water Reclamation Plant.

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SCHEDULING AND SITE ACCESS

Microbial aerosol monitoring was scheduled for the fall and spring before and after the initiation of plant operations. This schedule was prepared anticipating that studies would be initiated during the fall 1978, and that plant operations would begin during the summer 1979. Extensive delays were, however, encountered during 1978 and sampling was initiated on September 25 but terminated on October 24. Although studies were performed during this period, digested sewage sludge was hauled to the OWRP grounds and was actively applied to the landscape during some of the sampling trials. This sludge was hauled to the site on October 11, 12, 13, 18, 19, 20, 21, and 23, 1978. Because of the abbreviated study and because of sludge application during this sampling period, data from fall 1978 are not considered in statistical analyses.

The spring 1979 sampling period was during the period between April 4 and June 14, 1979. Because construction-related delays prevented commencement of operations at OWRP, baseline studies were also conducted during the fall 1979 season. Since the initiation of plant operations was delayed until May 1980, the spring 1980 sampling season was postponed until after plant start-up. After initial spring sampling on May 19, 1980, sampling was temporarily suspended but was then continued from June 18 to November 12, 1980. Those samples taken from May 19 through August 21, 1980 were designated as spring/summer samples, while those taken from August 26 through November 12, 1980 were referred to as fall samples.

FIELD SAMPLING APPROACH

The field studies were designed to determine the concentration of several kinds of microbial aerosols at varying locations from the center of the OWRP. These organisms included total aerobic bacteria-containing particles (TABCP), as determined with multistaged impactor- and rotating slit-type samplers, standard plate count organisms (SPC), total coliforms (TC), fecal coliforms (FC), fecal streptococcus (FS), *Klebsiella* sp. (KB) and other bacteria identified from TC colonies, *Salmonella* sp. (SA), coliphages (CP) of *Escherichia coli* C3000, and animal viruses (AV) isolated on Buffalo green monkey kidney (BGMK) and WI-38 cells.

Sampling instrumentation and procedures were selected and directed toward the goal of providing sufficient sampling and assay sensitivity to determine the concentration of microbial aerosols based on estimated potential human exposure during specified time intervals. Assuming human respiration rates of approximately 0.0125 m^3/min, the periods of exposure evaluated were approximately 1-2 hr (0.8-1.7 m^3) for TABCP and SPC, 8 hr (5-10 m^3) for TC, 24 hr (10-20 m^3) for FS and FC, 48 hr (30-60 m^3) for SA and CP, 1 mo (400-600 m^3) for AV. The significance of positive and nonpositive observations was dependent upon the proportion of the total air volume being sampled, which was very small in open air, and upon the efficiency of the collection and assay systems. With this in mind, observations are interpreted in view of the detection sensitivities attained. Samples were taken for defined time periods during the day- and nighttime using samplers with nonidentical air flow rates. Consequently, the amount of air sampled at each location, although similar, was not necessarily identical. Concentration of microorganisms as aerosols were, however, reported on the basis of a constant volume (1 m^3). The daytime period was designated as any time between 0800 and 1959 hr while the nighttime period was specified as that during the 2000 and 0759 hr interval.

Three different sampling schemes, each utilizing three kinds of microbial air samplers, were employed as shown in Table 1. Four sampling locations, using multistaged impactors, slit samplers, and "large volume" air samplers at each location, were utilized in schemes A and B, while two locations using similar samplers were utilized in scheme C. TABCP were determined under each scheme using both slit and multistaged impactor samplers. Slit samples were taken during the duration of each sampling trial to detect TABCP aerosol fluctuations over time while multistaged impactor samples were taken during each "large volume" air sampling period to characterize the TABCP aerosol aerodynamic size distribution. "Large volume" air samplers were used during sampling scheme A to study aerosols of TC, FC, FS, SPC, KB, and other organisms identified from TC colonies. In sampling schemes Bs and Bc, these samplers were used to study SA and CP, respectively. Using two "large volume" air samplers at each of two locations, AV were studied at sites 1 and 4 under scheme C.

EQUIPMENT UTILIZATION AND OPERATION

Slit Sampler

The design and principles of slit impactor type sampler operation were described by Bourdillon, et al. (1941) and similar samplers are now available commercially. This device is efficient for collecting 0.5 µm and larger particles by inertial impaction onto a large rotating agar-containing plate. Airborne particles are collected on rotating agar plates for determination of viable particle variations over time.

Four calibrated slit samplers (Matteson-Garvin Co., Maitland, FL), shown in Figure 2, with an air flow rate of approximately 0.03 m^3/min were used in this study. Each sampler was swabbed with 70% ethyl alcohol in the field prior to loading with a plastic 150 mm petri dish, containing 70 ml of trypticase soy agar (TSA) with 0.01 to 0.02% cycloheximide and coated with 0.2% oxyethylene docosanol (OED-Green). After indicating the starting point on each dish, the slit-to-agar distance was adjusted to the manufacturer's recommended height and sampling was initiated for 30 min to 1 hr. After sampler shut-off, the dishes were covered, labeled, and stored until the end of the sampling trial when they were transported to the laboratory and incubated at 35 ± 5.0°C for 48 ± 3 hrs.

Multistaged Impactors

Multistaged impactors (Andersen, 1958) permit aerodynamic particle sizing by impaction onto the surface of staged agar-containing plates at increasing velocities. Four Andersen samplers, shown in Figure 3, with calibrated pumps having an air flow rate of approximately 0.03 m^3/min were utilized. Special glass petri dishes were filled with 27 ml of TSA containing cycloheximide and

TABLE 1. FIELD SAMPLING APPROACH

Sampling Scheme	No. of Sites[a]	Specific Assays per Sampler Multistaged Impactor	 Slit Sampler	 "Large Volume" Air Sampler
A	4	TABCP[b]	TABCP	TC, FC, FS, SPC, KB[c]
Bs	4	TABCP	TABCP	SA
Bc	4	TABCP	TABCP	CP
C	2	TABCP	TABCP	AV[d]

[a] All sites were not always utilized due to operational difficulties.

[b] Total aerobic bacteria-containing particles (TABCP); standard plate count organisms (SPC); total coliforms (TC); fecal coliforms (FC); fecal streptococcus (FS); *Klebsiella* sp. (KB); *Salmonella* sp. (SA); coliphages (CP); animal viruses (AV).

[c] KB were identified with other bacterial species from TC colonies.

[d] Two samplers used per site.

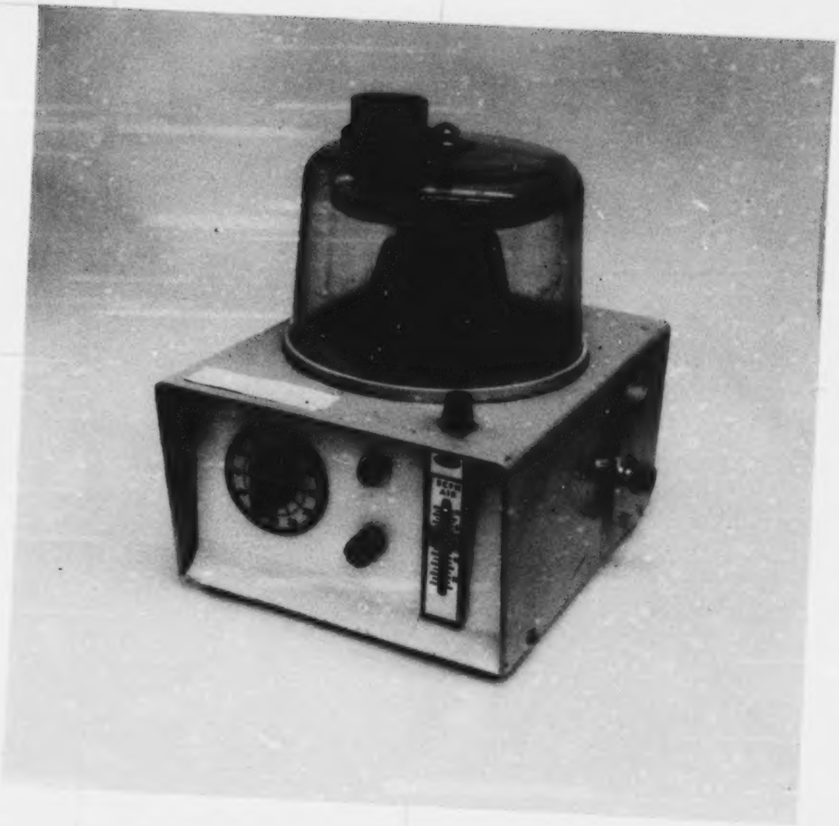

Figure 2. Slit sampler.

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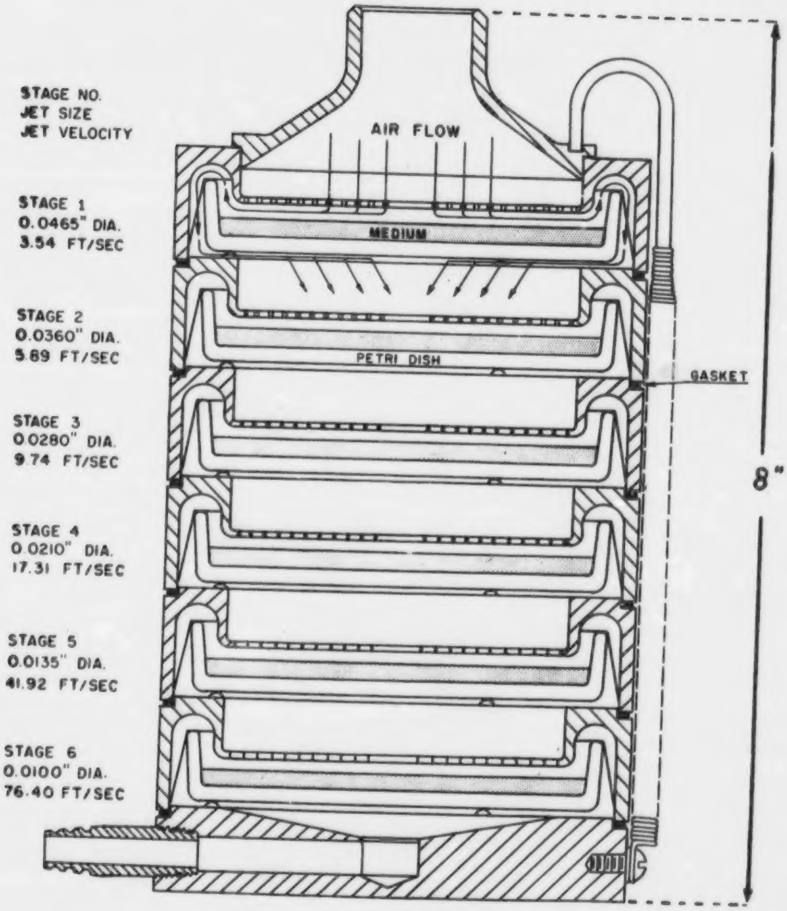
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GASKET
STAGE 3
0.0280" DIA.
9.74 FT/SEC
8"
STAGE 4
0.0210" DIA.
17.31 FT/SEC
STAGE 5
0.0135" DIA.
41.92 FT/SEC
STAGE 6
0.0100" DIA.
76.40 FT/SEC

Figure 3. Andersen multistaged impactor sampler

coated with OED, as described. Six agar-filled dishes per sampler were loaded in the field following sampler surface scrubbing with 70% ethanol. Air sampling was performed for 30 min duration during large volume air sample collection. Sample-containing petri dishes were removed from each sampler, labeled, and stored until transport to the laboratory for incubation at 35 ± 0.5°C for 48 ± 3 hr.

Large Volume Air Samplers

Two kinds of large volume air samplers were used in this study. The first was the Litton Model M Large Volume Air Sampler, (LVAS), similar to that illustrated in Figure 4 while the second was a large volume cyclone scrubber (LVS) as shown in Figure 5. The LVAS collected airborne particles by electrostatic precipitation from about 1 m^3/min of air, while the LVS employed impaction into a cyclone scrubber at an air sampling rate of about 0.6 to 0.9 m^3/min for airborne particle collection. The LVAS was used during the fall 1978, while the LVS was used for the remaining phases of the project. Since the data collected with these two sampler types are not necessarily comparable, statistical analyses were performed only on data obtained with the LVS samplers, which was used during four study sessions. Use of the LVS was required, since the five LVAS' were made unavailable to this project after the fall 1978 sampling period.

During the fall period, significant difficulties were experienced in the field with the LVAS, resulting in some uncollectable samples on certain dates at specific sampling sites. These difficulties were primarily associated with sampling fluid losses, and related arcing and electrical failure from peristaltic pump tubing or sample pick-up areas. Since LVAS sample collection components are designed into the same housing as the electrical and metering components, autoclaving was not feasible. Live steam and ultraviolet irradiation was found to be effective for sampler decontamination between sampling trials. To ascertain the effectiveness of the decontamination procedure and to detect potential sampler contamination during peristaltic pump adjustment, sterility controls were employed for each test organisms.

The LVS was found to be simpler than the LVAS in both operations and sterilization. The air sampling rate of each LVS was affected by slight design and air blower variations, but ranged from 0.6 to 0.9 m^3/min. Although operation was relatively simple, difficulties were occasionally encountered with the peristaltic pumps. Sampler sterilization was by conventional autoclaving and, consequently, sterility was ascertained prior to field use.

The large volume air sampling fluid was selected for assay system compatability. One-quarter strength trypticase soy broth (TSB) was used for TPC, TC, FC, FS, and KB, 50% dulcitol selenite broth (DSE) for SA, 25% phage assay broth (PAB) for CP, and 25% nutrient broth in Hanks balanced salt solution (HBSS) for AV collection. A schematic diagram of the LVS sampling set-up is shown in Figure 6. During air sampling, the particle-laden fluid was aseptically collected in serum stoppered bottles and, during aerosol virus sample collection, the fluid was recirculated and sterile distilled water was aseptically added to the collection reservoir to replace evaporation losses. The collected samples were maintained on wet ice or in an appropriate cooling

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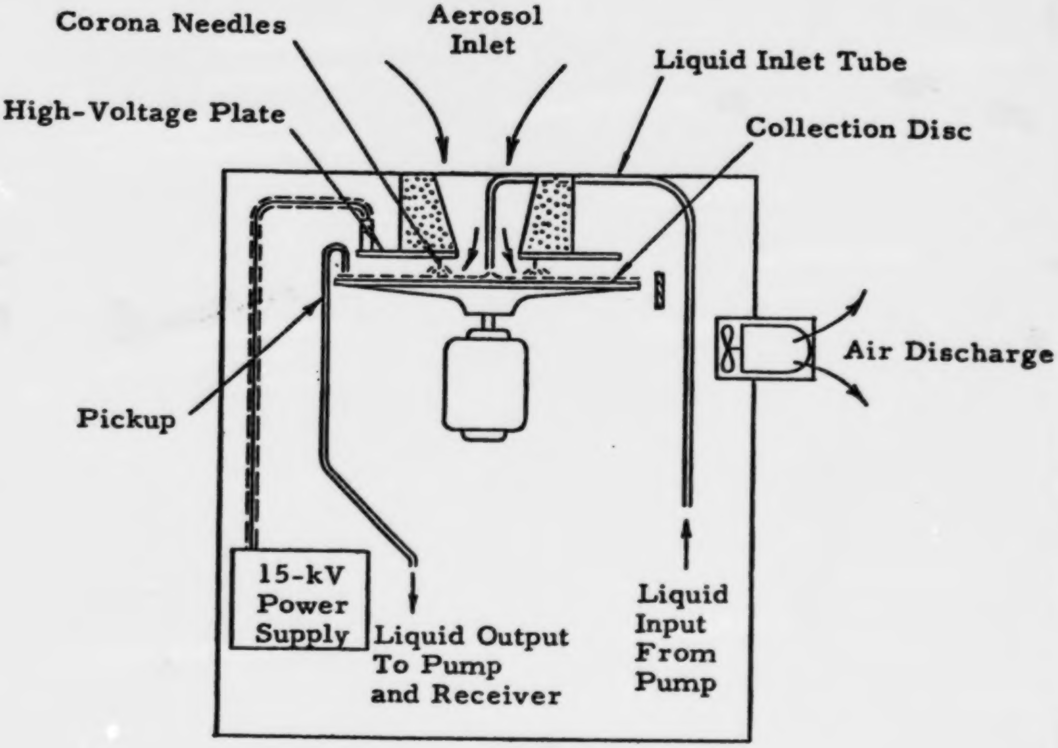
Corona Needles
Aerosol Inlet
Liquid Inlet Tube
High-Voltage Plate
Collection Disc
Air Discharge
Pickup
15-kV Power Supply
Liquid Output To Pump and Receiver
Liquid Input From Pump

Figure 4. Litton large-volume air sampler.

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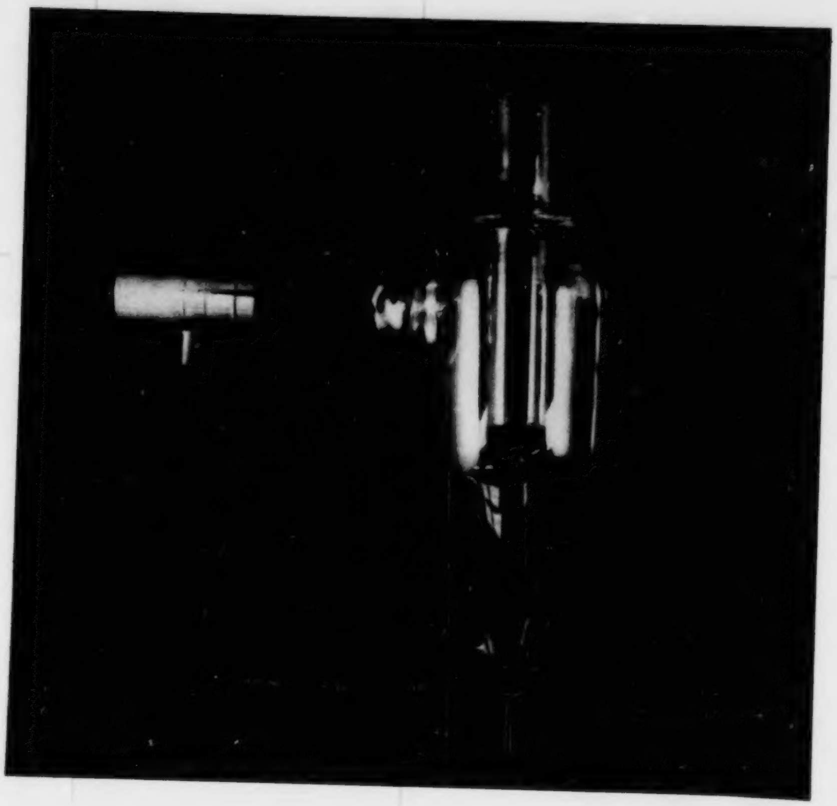

Figure 5. Glass cyclone scrubber sampler.

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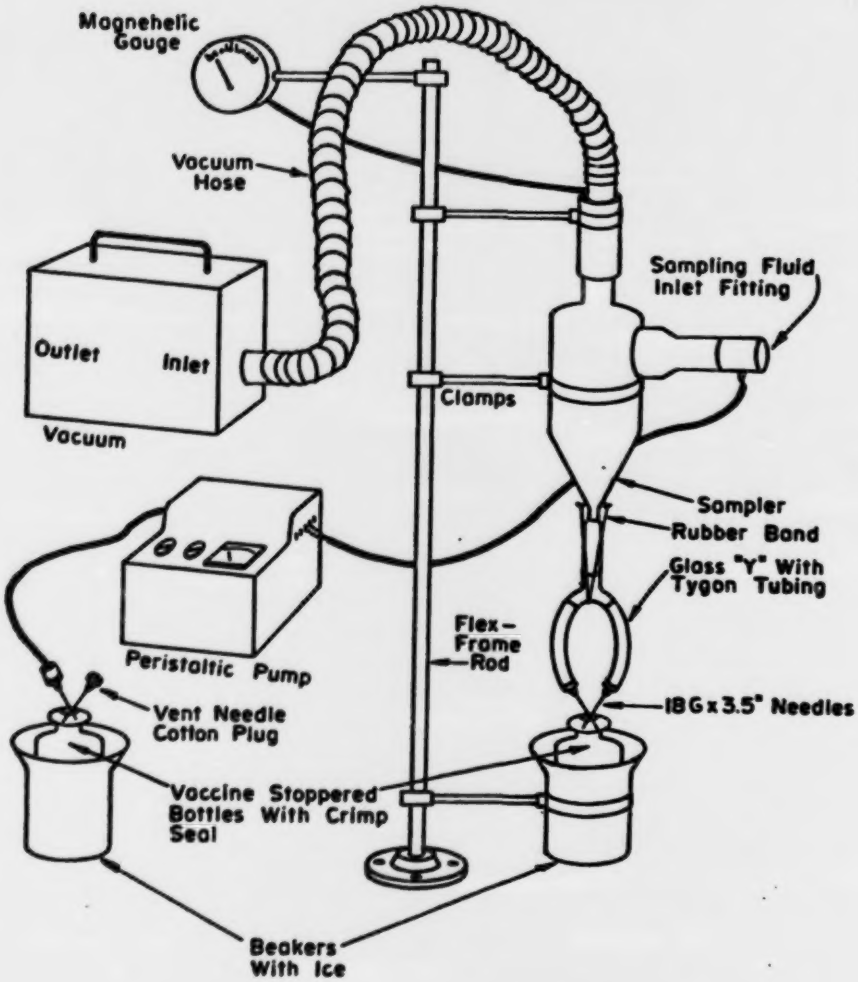
Magnehelic Gauge
Vacuum Hose
Outlet
Inlet
Vacuum
Sampling Fluid Inlet Fitting
Clamps
Sampler
Rubber Band
Glass "Y" With Tygon Tubing
Peristaltic Pump
Flex-Frame Rod
18G x 3.5" Needles
Vent Needle Cotton Plug
Vaccine Stoppered Bottles With Crimp Seal
Beakers With Ice

Figure 6. Glass cyclone sampling apparatus.

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device during the sampling processing as well as during transport and subsequent laboratory assay.

ASSAY AND ENUMERATION

Air sample assays were based on the ability of collected microorganisms to replicate and produce observable characteristics such as colony growth, plaque formation, or cytopathic effect in a specified medium or host cell system. Methods of counting and enumeration were as indicated in Standard Methods, 14th Ed. (1975) or as described herein. A summary of the media and reagents used in this study is presented in Appendix D. Countable characteristic colonies of TABCP, TCP, TC, FC, FS, and KB were expressed as colony forming units (cfu) per volume (m^3) of air.

TABCP were assayed after collection with multistaged impactor or slit samplers on TSA-containing cycloheximide and coated with oxyethylene docosanol (OED), as described, colonies were counted under magnification, and then expressed as cfu/m^3 of air.

Each collected "large volume" air sample was removed from its transporting ice bath, mixed by inverting 25 times, measured, and brought to its original sampling fluid volume with sterile distilled water. These samples were assayed for either SPC, TC, FC, FS or SA or CP or AV.

SPC was assayed from LVS fluid using tryptone glucose yeast extract agar. Duplicate 1 ml portions of appropriate sample dilutions were placed in sterile tubes with at least 12 to 15 ml of liquefied medium at 44 to 46 C, and, after solidification, incubated at 35 ± 0.5°C for 48 ± 3 hr. Colonies were counted using a Quebec colony counter and expressed as cfu/m^3 of air.

TC were assayed from LVS fluid using the membrane filtration (MF) technique. Duplicate portions of appropriate sample volumes were filtered through 0.45 μm membrane filters of 47 mm diameter, placed on m-Endo broth saturated pads, contained in petri dishes, and incubated at 35 ± 0.5°C for 24 ± 2 hr. Colonies developing a characteristic metallic sheen were counted under fluorescent light using a binocular dissecting microscope. Concentrations were expressed as cfu/m^3 of air.

FC were also assayed from LVS fluid by the MF procedure. Duplicate sample portions were filtered using m-FC medium, placed in water-tight containers, and incubated in the waterbath at 44.5 ± 0.2°C for 24 ± 2 hr. Characteristic blue colonies were counted using a binocular dissecting microscope and expressed in terms of cfu/m^3 of air.

FS assays from LVS fluid were performed in duplicate on KF streptococcus agar with the MF procedure. After incubation for 48 ± 3 hr at 35 ± 0.5°C, characteristic red to pink colonies were counted using a binocular dissecting microscope and the concentrations expressed as cfu/m^3 of air.

After TC colonies had been counted, they were picked, transferred to TSA slants, incubated at 35 ± 0.5°C for 24 ± 2 hr, and stored at 4°C until used for identification. For identification, the slant cultures were streaked onto

TSA plates, incubated at 35 ± 0.5°C for 24 ± 2 hr, and isolated colonies were picked and differentiated by API 20E strips (Analytab Div. of Ayerst Labs, Inc.) using the API analytical profile index subscription for Enterobacteriaceae with the oxidase test. If identification was not satisfactory, the culture was restreaked and the differentiation was repeated. The identity of cultures characterized as "excellent, very good, or acceptable" were reported. All other cultures, including those found to be nonviable during identification procedures, were reported as "No I.D." or "No Growth."

The most probable number (mpn) method was used for estimating SA and CP concentrations. Calculation of mpn plaque forming units (pfu) or viable units (vu) per sample was performed by a method described by Cochran (1950) and by Chang (1966) for detecting small quantities of virus in undiluted fluids. The pfu, or vu density (d or mpn) in a particular sample was estimated by $s/n = e^{-d}$ where s was the number of negative cultures and n was the total number of cultures in the test. The mpn (d) was then determined by $mpn = \ln (s/n)$. The 95% confidence limits (P) mpn estimates were determined by $P \pm = 2(pq/n)^{1/2}$ where p was the percent positive culture, q was the percent negative culture, and n was the total number of cultures used. The results were expressed in terms of mpnpfu or mpnvu per m^3 of air for CP and SA, respectively.

SA assays were performed by application of the method of Kenner and Clark (1974) to the mpn procedure. After sample volume adjustment, three ml samples were added to tubes containing concentrated DSE to provide a final single-strength DSE concentration. After positive and negative controls were inoculated, all tubes were agitated for mixing and incubated in a 40°C waterbath for 24 ± 2 hr. An inoculum from the incubated DSE tubes was streaked onto quadrants of xylose lysine desoxycholate (XLD) agar plates and incubated for 24 hr at 37°C. Black colonies from the XLD plates were restreaked on TSA slants and identified with the API system. Confirmed SA was expressed in terms of mpnvu per m^3 of air.

CP assays were performed on Escherichia coli C3000. This strain was selected because it is a host for RNA-containing coliphages, such as MS-2, which, in certain studies was shown to be stable in aerosols (Dubovi and Akers, 1970) and because it was used successfully in previous studies of the aerosols around wastewater treatment facilities (Fannin, et al., 1977). CP assays were made from LVS fluid following sample measurement, volume adjustment, and filtration through 0.2 μm pore filters. PAB concentrates were diluted by each sample to bring the medium to single strength concentration. Each tube was then inoculated with a 4-hr culture of Escherichia coli C3000, vigorously agitated, and incubated 18 to 24 hr at 37°C. For each set of dilution tubes, a lawn of the host bacteria was prepared by distributing 2.5 ml of E. coli C3000-inoculated PAB, containing 0.7% agar and held at 45°C, onto a host lawn using a sterile wooden applicator stick, the plates incubated for 5-12 hrs and examined for bacterial lysis at each inoculated area. Clear zones in the spotted area were considered as evidence of the presence of plaque-forming CP. The results were reported as mpnpfu per m^3 of air.

Samples for AV analysis were divided into two portions. The first portion was assayed by detection of cytopathic effect (cpe). If this sample portion was found negative for AV, then the second portion was assayed for cpe. If the first portion was positive for AV, then the second portion was assayed by the plaque method. The number of positive cpe cultures or pfu per volume of air sampled was reported.

Sampling fluid for AV assays from the two LVS at each sampling location was pooled and mixed by vigorous agitation. The final pooled fluid volume, estimated to be approximately 100 ml, was sonicated for 15 sec at 4.5 amps with a Sonicator (Model W-375 Heat Systems-Ultrasonics, Inc.), filtered through a 47 mm dia. 0.2 μm heat-inactivated fetal calf serum-pretreated Millipore membrane filter, and divided into two equal portions (A and B) and held at —70°C until assayed. The two portions were assayed for AV detection as described above.

Virus assays were performed on BGM or WI-38 cell monolayers washed twice with HBSS. Five 5 ml sample portions were added to 75 cm^2 flasks containing each cell system. Twenty-five cm^2 flasks monolayered with each cell system were used in duplicate for positive virus and cell controls. The flasks were inoculated with 1.7 ml HBSS or an appropriate dilution of poliovirus type 1. Positive virus controls were inoculated in a separate laminar flow hood. The inoculum was distributed over the cell monolayer and a 2 hr virus adsorption period, with periodic agitation, was permitted. Following the adsorption period, the cultures were washed twice with HBSS before overlay with the 15-20 ml fluid or agar-based minimum essential medium (MEM).

The fluid MEM, as used in cpe assays, contained 2% heat inactivated fetal calf serum (HIFCS), 10-25 mM HEPES buffer, 50 μg/ml Gentamicin, and 2.5 μg/ml Fungizone. Fluid overlay cultures were microscopically examined for CPE during incubation at 37°C for 7 days or until the cell monolayer was lost. The liquid medium from cultures showing cpe was subpassaged, along with appropriate positive and negative virus controls, by inoculating 0.5 ml into duplicate washed monolayered homologous cell culture tubes. Following a 2/hr virus adsorption period, the samples were overlaid with MEM containing 2% HIFCS and incubated at 37°C for microscopic determination of cpe. Cultures demonstrating cpe were considered positive for virus when the test was validated by the control cultures. Virus isolates were identified by serum neutralization using Lim-Benyesh-Melnick pooled antisera.

The agar overlay medium was MEM supplemented with 2% HIFCS, 4% of 1:1000 dilution neutral red, 1% of 50% $MgCl_2 \cdot 6H_2O$, 50 μg/ml Gentamicin, 2.5 μg/ml Fungizone, and 1.0% Difco-Bacto agar. This agar medium was held at 45°C during cell overlay. Cultures were incubated in the dark at 37°C and examined for plaques after 3, 5, and 7 days or until the cell monolayer was lost. All plaques were picked and suspended in 2 ml HBSS containing 10-25 mM HEPES buffer, 100 units penicillin, 100 μg/ml streptomycin, and 2.5 μg/ml Fungizone. For virus confirmation, 0.5 ml of plaque suspension was inoculated and examined for cpe. Virus isolates were identified by serum neutralization.

QUALITY ASSURANCE

Prior to use and periodically throughout the project, each sampler was calibrated to determine air flow rates using a precalibrated mass flow meter or anemometer. All samplers were numbered and each collected sample was identified with a particular instrument. Loading and unloading of control Andersen and slit agar plates was performed at a field station to determine potential contamination during sample handling. Prior to use, LVS samplers were autoclaved at a minimum of 15 lbs for 15 min.

During sample assay, two negative and two positive organism control assays were performed for each field trial. For the positive controls, suitable dilutions of appropriate organisms were used for each test group. That is, Enterobacter aerogenes, Escherichia coli, Streptococcus fecaelis, Klebsiella pneumoniae, Salmonella enteritidis, MS-2 phage, and poliovirus type 1 were used for TC, FC, F, KB, SA, CP, and AV tests, respectively. Periodic bacterial assays for SPC using tryptone glucose extract agar and by the spread plate procedure on TSA were used to confirm the SPC technique and the TABCP medium. These positive controls, used for validation of the assay system for the groups of organisms which may either be found in very low numbers or be totally absent in a given sample, were qualitatively rather than quantitatively estimated.

To minimize the possibility of cross contamination, positive control assays were performed after sample assays. In addition, positive AV control assays were always performed in a separate laminar flow hood from that used for sample assays. Virus isolates were stored at —70°C in a locked freezer containing no other viruses stocks. Plates to be used for TABCP determinations were incubated 24 hr at 35°C prior to use. Evidence of colonial growth on the plates mandated their discard.

Quality control programs for the various research studies being conducted in the laboratories were incorporated into the study. All methodologies were standardized to assure agreement, when applicable, with procedures outlined in Standard Methods, 14th Ed. (1975).

DATA ANALYSES

The primary null hypothesis is that the aerosol concentration of each microbial parameter in the vicinity of the OWRP is the same before and after initiation of plant operations at a given sampling location for a specified season on diurnal condition. That is,

$$H_o: C_{bijkl} = C_{aijkl}$$

where:

C_b = microbial aerosol concentration before plant operation

C_a = microbial aerosol concentration after plant operation

i = 1, 2,...10: microbial parameter (TABCP [S], TABCP [A], SPC, TC, FC, FS, KB, SA, CP, and AV)

j = 1, 2: season (fall and spring/summer)

k = 1, 2: diurnal condition (day- and nighttime)

1 = 1, 2, 3, 4: sampling location (< 150 m, 150-250 m, and > 250m downwind from center of aeration tanks; upwind).

The sampling program was designed, within resource limits, to place greater emphasis on a smaller number of sensitive samples than upon a larger number of insensitive samples.

To test the H_o, data were collected under a wide range of meteorological conditions. The validity of statistical analyses of such data requires that the assumptions underlying the specific analysis be met. Because of the limited number of observations, such assumptions as homoscedasticity and normality of the test populations cannot be tested and, because of field study variables, cannot be assumed. Consequently, the nonparametric Mann-Whitney U test (Siegel, 1956) was employed to test the H_o at $\alpha = 0.01$ against the alternative hypothesis, H_1, that the specific microorganism concentrations increased after plant operations were initiated.

The secondary and tertiary H_o was that the microbial aerosol concentration at each sampling site was the same during day as nighttime and spring/summer as fall, respectively. The Mann-Whitney U test was also used to test these hypotheses ($\alpha = 0.01$) against the H_1 that these concentrations were not the same under the respective conditions of comparison.

The final null hypothesis was that microbial aerosol concentration at each sampling location was independent of the meteorological or plant operating conditions. The Spearman Rank Correlation Coefficient (Siegel, 1956) was applied separately for determination of significant correlations ($\alpha = 0.01$) between microbial aerosol concentrations and windspeed, relative humidity, temperature, sewage flow rate, and plant aeration rate.

The geometric mean ($\overline{X}_G$) of specific microbial aerosol concentrations were determined in terms of detectable units (e.g. cfu, pfu, mpnpfu, mpnvu) per m^3 of air for positive samples. The $\overline{X}_G$ for these samples was determined for total and for day- and nighttime observations. during each sampling season. The $\overline{X}_G$ was calculated by determining the n^{th} root of the product of the individual observations.

$$(\overline{X}_G = \sqrt[n]{x_1 . x_2 . . . x_i})$$

When some samples contained "zero" observations (i.e., below the detection sensitivity of the methods employed), the geometric mean could not be determined by this procedure. To exclude all samples from the data presentation would result in a significant over estimation of microbial aerosol concentrations for some parameters present in low concentrations. Consequently, these means were weighted by multiplying by p/n where p is the number of positive and n is the total number of observations. A similar procedure is described by Snedecor and Cochran (1967).

SECTION 5

RESULTS AND DISCUSSION

TOTAL AEROBIC BACTERIA-CONTAINING PARTICLES

Slit Samplers

A total of 885 valid individual samples were collected during the study period and, because data from the first fall season were excluded, statistical analyses were performed on only 814 samples. These data are summarized by date in Appendix C. Differences were observed between day- and nighttime aerosol TABCP concentrations as shown in Figure 7, the geometric mean TABCP aerosol concentrations at night (2000 to 0759 hrs) exceeded those observed during the day (0800 to 1959 hours) at all sampling sites, except at the >250 m downwind location before plant operations, and at all sampling sites during plant operations. For all samples collected during 1979 and 1980, these differences were highly significant ($p < 0.001$) at the < 150m and 150 to 250 m downwind and at the upwind sampling sites and were significant ($p < 0.01$) at the > 250 m downwind site. Because such differences exist, the day and night data are separated for both presentation and analyses.

Few statistically significant differences were noted between before and after plant operations. The TABCP nighttime aerosol concentration at < 150 m downwind increased significantly ($p < 0.001$) from 59 to 218 cfu/m^3, after plant operations were initiated. This nighttime concentration at the other sampling locations before and during plant operations, respectively, were 75 and 116 cfu/m^3 at 150 to 250 m downwind, 52 and 98 cfu/m^3 at > 250 m downwind and 66 and 67 cfu/m^3 at the upwind locations. None of these concentration increases were, however, determined to be statistically significant ($p > 0.01$). The daytime TABCP concentrations were generally lower than those observed at nighttime. Before and during plant operations, respectively, these daytime concentrations were found to be 34 and 57 cfu/m^3 at < 150 m downwind, 28 and 35 cfu/m^3 at 150 to 250 m downwind, 67 and 51 cfu/m^3 at > 250 m downwind, and 30 and 35 cfu/m^3 at the upwind locations. Although some concentration increases were observed at all sites, except > 250 m downwind which decreased, none of the differences in these daylight concentrations were found to be significant.

Analyses of these nighttime TABCP data by sampling season, as shown in Figure 8, demonstrate that the greatest concentration differences occurred during the pre- and post-operation fall sampling seasons at sites within 150 m downwind of the aeration tanks. This concentration increased significantly ($p < 0.001$) from 72 to 276 cfu/m^3 before and during plant operations during the fall. Although TABCP concentration increases were also observed during the fall at all other sampling sites, including the upwind location, none of

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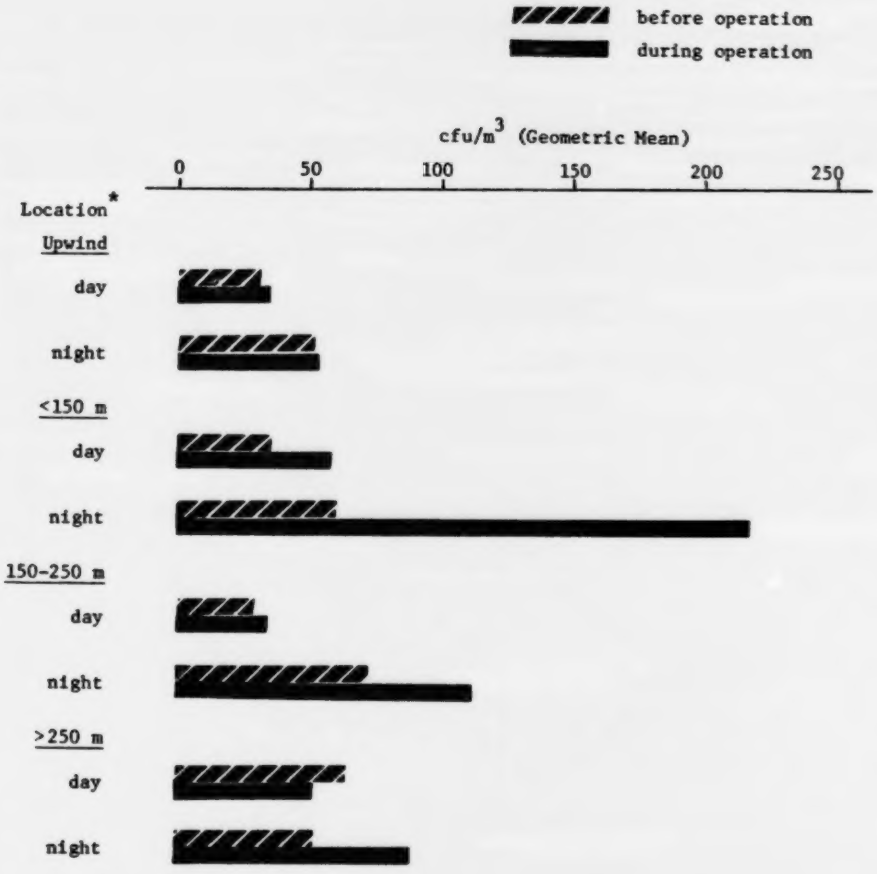

*With respect to center of aeration tanks; distances are downwind.

Figure 7. Total aerobic bacteria-containing particles with slit sampler during day- and nighttime.

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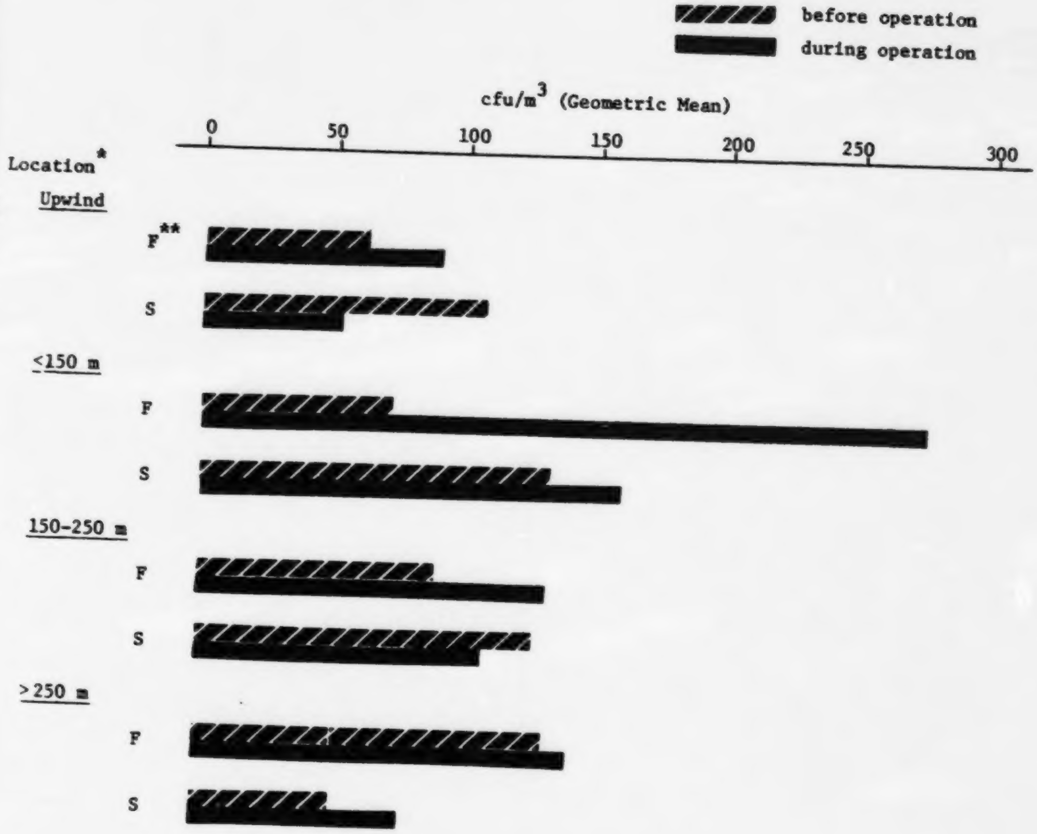

* With respect to center of aeration tanks; distances are downwind.

** F refers to Fall and S refers to Spring or Spring/Summer seasons.

Figure 8. Total aerobic bacteria-containing particles with slit sampler at night by season.

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these increases was significant. During the pre- and post-operation spring/summer sampling period, no significant increases in TABCP concentration were observed at any site, and decreases were seen at 150 to 250 m downwind and at the upwind locations.

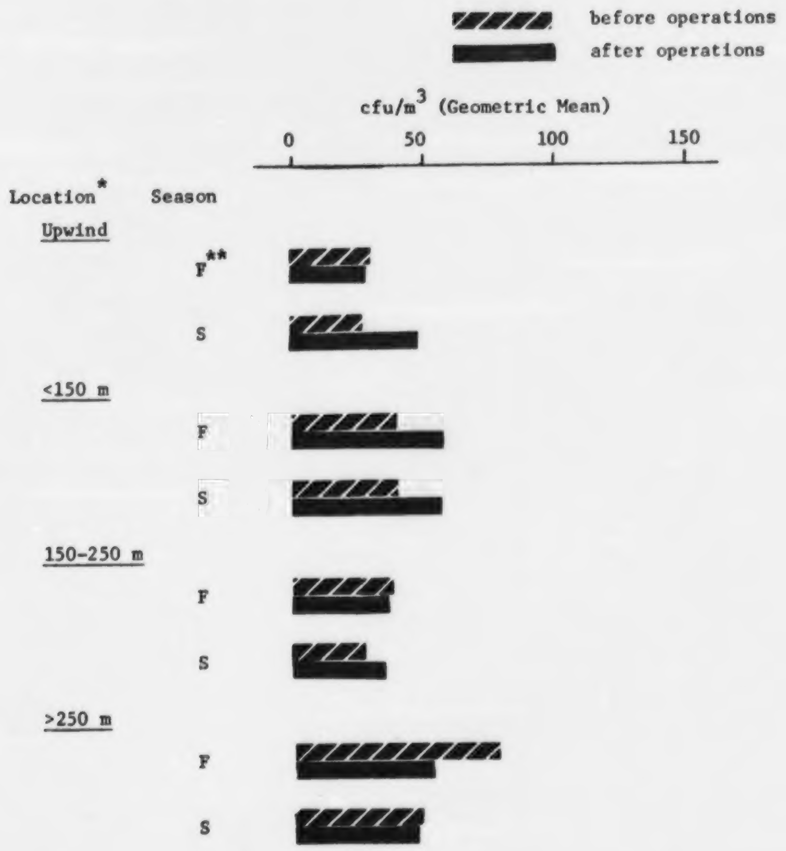
Daytime TABCP concentrations, shown in Figure 9, did not increase significantly during either season after plant operation commencement at any sampling distance. The concentration at the < 150 m downwind sites was 32 and 58 cfu/m^3 during the pre- and post-operational fall seasons and was 42 and 55 cfu/m^3 during the pre- and post-operation spring/summer seasons. The TABCP concentrations were slightly lower at > 250 m downwind during the daytime after commencement of plant operations during the fall (77 cfu/m^3 before and 54 cfu/m^3 during operations) and spring/summer (50 cfu/m^3 before and 46 cfu/m^3 during operations).

The variability of slit sampler-determined TABCP concentrations with season were evaluated by comparing each 1979 and 1980 sampling season with each other season. Differences were determined to be significant at $p < 0.01$ using a two tailed Mann-Whitney U test. Figure 10 illustrates the season pairs showing significant concentration differences by sampling distance from the plant. At < 150 m downwind, no significant differences were observed between any sampling seasons during the daylight. Highly significant ($p < 0.001$) nighttime differences were, however, observed at this location between the fall of 1979 and 1980 with TABCP concentrations of 72 and 276 cfu/m^3, respectively; and between the spring of 1979 and the fall of 1980, with concentrations of 131 and 276 cfu/m^3, respectively. Other significant ($p < 0.01$) differences were observed between the fall of 1979 and spring/summer 1980, with concentrations of 72 and 162 cfu/m^3, respectively, and between spring/summer 1980 and fall 1980. No significant seasonal concentration differences were observed at the 150 to 250 m or > 250 m downwind sampling sites. Significant ($p < 0.001$) differences were, however, observed at nighttime at upwind locations between spring 1979 and spring/summer 1980, with concentrations of 109 and 51 cfu/m^3, demonstrating a concentration decrease during plant operation. A difference ($p < 0.01$) was also observed during the daylight between these two seasons. The TABCP concentration during the day, however, increased from 26 cfu/m^3 in the spring 1979 to 48 cfu/m^3 in the spring/summer 1980.

Andersen Samplers

A total of 571 samples, each containing 6 countable plates, were taken in this study, 534 samples containing 3,204 countable plates were included for statistical analyses. Analyses were performed on individual samples and the data are summarized by sampling date in Appendix C.

TABCP aerosol concentrations determined with Andersen samplers generally exceeded those observed using slit samplers. The differences between day- and nighttime aerosol concentrations were found to be lower with Andersen than with slit samplers. Significant ($p < 0.01$) differences between day- and nighttime observations were found at the < 150 m downwind sites during the fall 1980, and at the upwind locations during the spring 1979.



* With respect to center of aeration tanks; distances are downwind.

**F refers to Fall and S refers to Spring or Spring/Summer seasons.

Figure 9. Total aerobic bacteria-containing particles with slit sampler during daylight by season.

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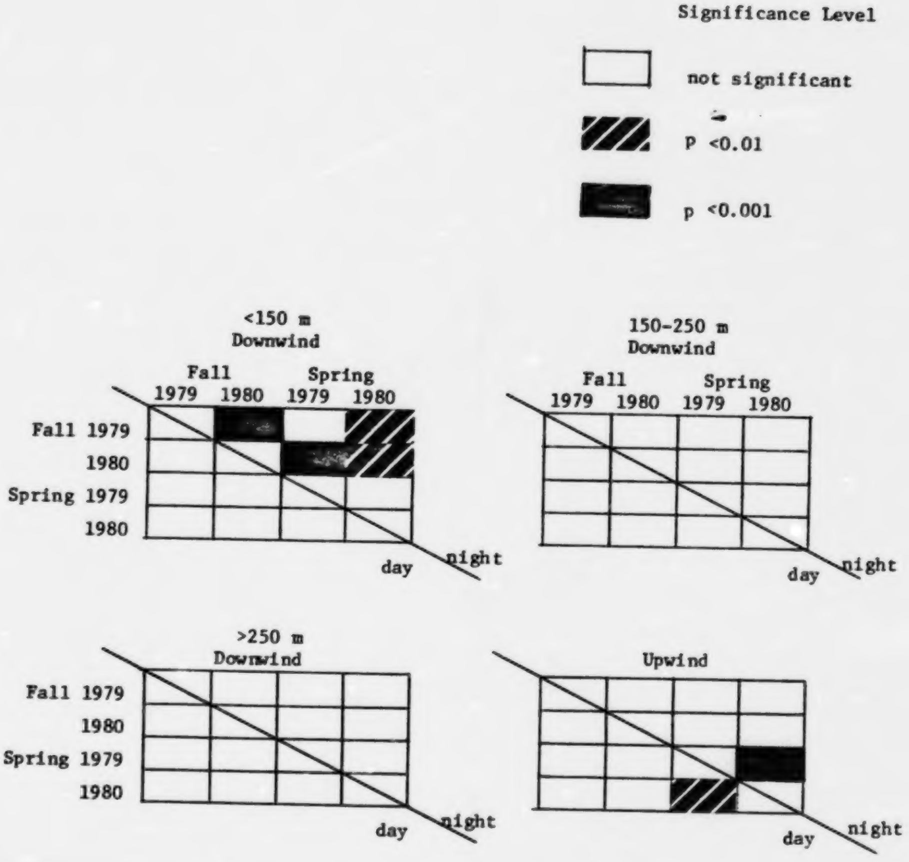

Figure 10. Significance of slit sampler total aerobic bacteria-containing particle differences by season.

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Figure 11 shows that significant ($p < 0.01$) TABCP concentration increases were observed at < 150 m downwind, during both day- and nighttime sampling, after plant operations were commenced. These increases were from 87 to 234 cfu/m^3 during the daytime and from 125 to 281 cfu/m^3 at nighttime. The TABCP concentration increases observed at 150 to 250 m downwind during both the day- and nighttime and at > 250 m downwind during the daytime were not significant ($p > 0.01$).

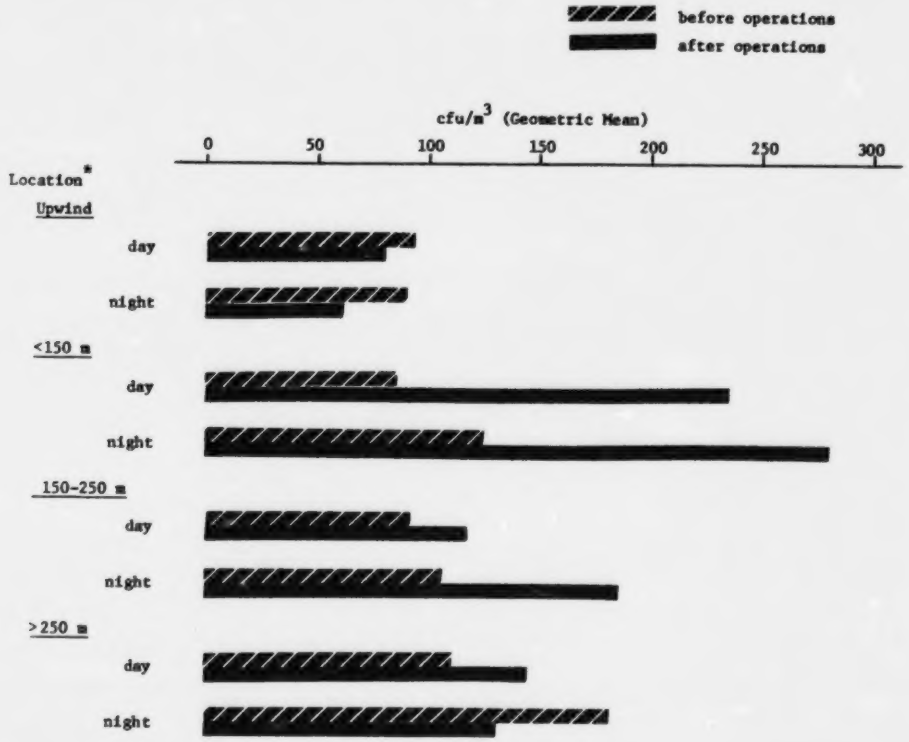
Examination of these observations by season and during the nighttime (Figure 12) showed that, at < 150 m downwind, the TABCP aerosol concentration increased significantly ($p < 0.001$) to 373 cfu/m^3 during the fall after plant operations were initiated from 102 cfu/m^3 as observed during the similar period before plant operations. No significant increases were observed during the spring/summer period at < 150 m downwind, nor during either sampling season at sites located 150 to 250 m downwind. Lower TABCP concentrations were observed at sites > 250 m downwind and at upwind locations during both sampling seasons at night after commencement of plant operations than before such operations began.

Daytime Andersen sampler observations (Figure 13) also showed highly significant ($p < 0.0001$) TABCP concentration increases (65 to 272 cfu/m^3) at < 150 m downwind during the fall after initiation of plant operations. No significant daytime concentration increases were observed at < 150 m downwind during the spring/summer sampling seasons, nor at any other location during either sampling season.

The variability of Andersen sampler-determined TABCP concentrations with season were evaluated by comparing each 1979 and 1980 sampling season with each other season. Differences were determined to be significant at $p < 0.01$ using a two tailed Mann-Whitney U test. Figure 14 illustrates the season pairs showing significant concentration differences by sampling distance from the plant. At < 150 m downwind, significant differences ($p < 0.001$) were seen during both day- and nighttime, between fall 1979 and fall 1980 periods, indicating a significant TABCP aerosol concentration increase after the initiation of plant operations. A significant ($p < 0.001$) difference in concentration was also observed from the spring/summer 1980 to the fall 1980 period during the day. This concentration increased from 134 to 272 cfu/m^3. A similar difference was not observed from nighttime sampling during these two seasons. Significant ($p < 0.01$) differences between spring 1979 and fall 1980 concentrations were, however, observed during both the day- (144 to 272 cfu/m^3) and nighttime (194 to 373 cfu/m^3) at sites < 150 m downwind. No significant concentration differences were seen between any sampling seasons at locations 150 to 250 m or > 250 m downwind during either the day or night and a significant ($p < 0.01$) difference was seen during the day at upwind sampling locations between the spring (64 cfu/m^3) and fall 1979 (140 cfu/m^3), two pre-plant operation sampling seasons.

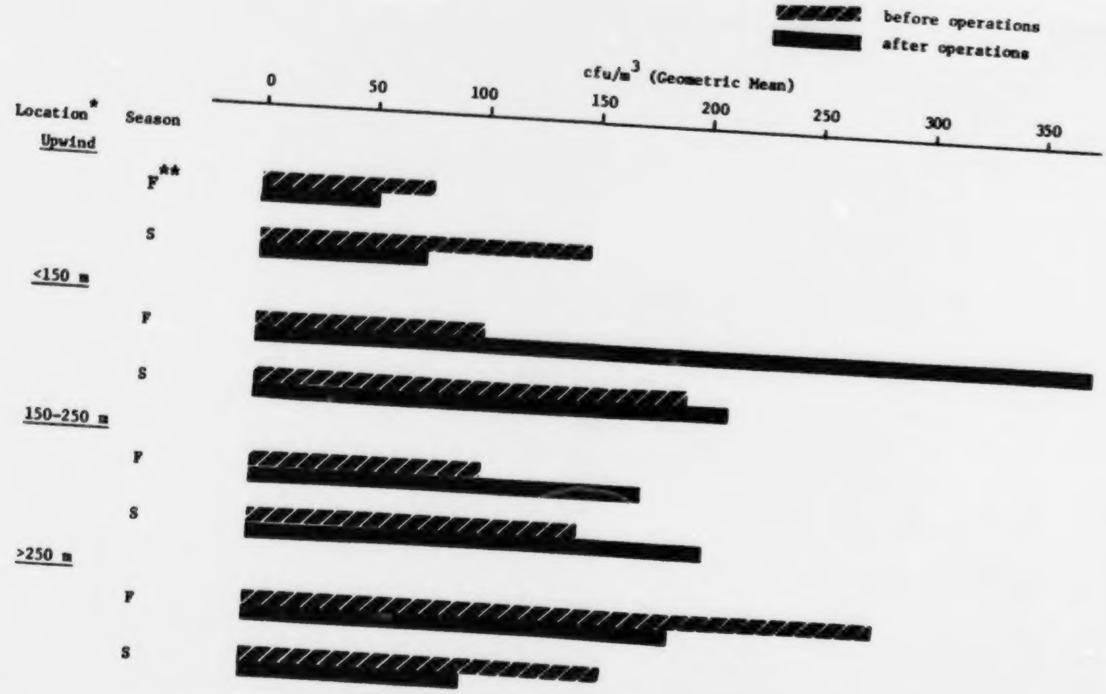
Effect of Sunlight on Slit Sampler TABCP Recovery

Because the TABCP concentration determined by slit samplers differed significantly between day- and nighttime samples, and because a previous investigation (Fedorak and Westlake, 1978) reported that significantly more



*With respect to center of aeration tanks; distances are downwind.

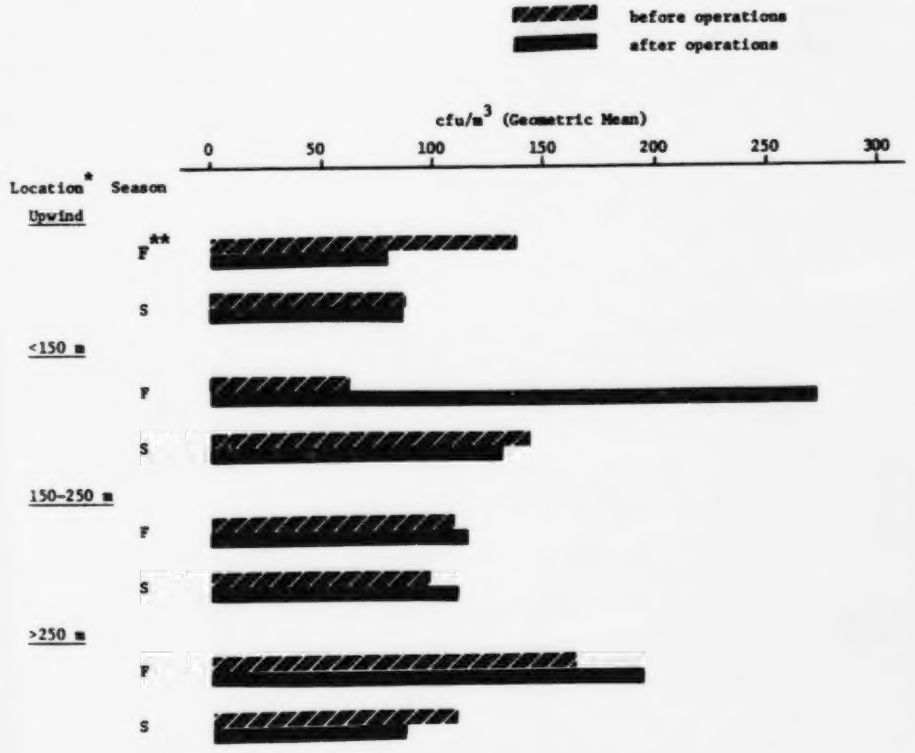
Figure 11. Total aerobic bacteria-containing particles with Andersen sampler during day- and nighttime.



[*] With respect to center of aeration tanks; distances are downwind.

[**] F refers to Fall and S refers to Spring or Spring/Summer seasons.

Figure 12. Total aerobic bacteria-containing particles with Andersen sampler at nighttime by season.



* With respect to center of aeration tanks; distances are downwind.

**F refers to Fall and S refers to Spring or Spring/Summer seasons.

Figure 13. Total aerobic bacteria-containing particles with Andersen sampler at daytime by season.

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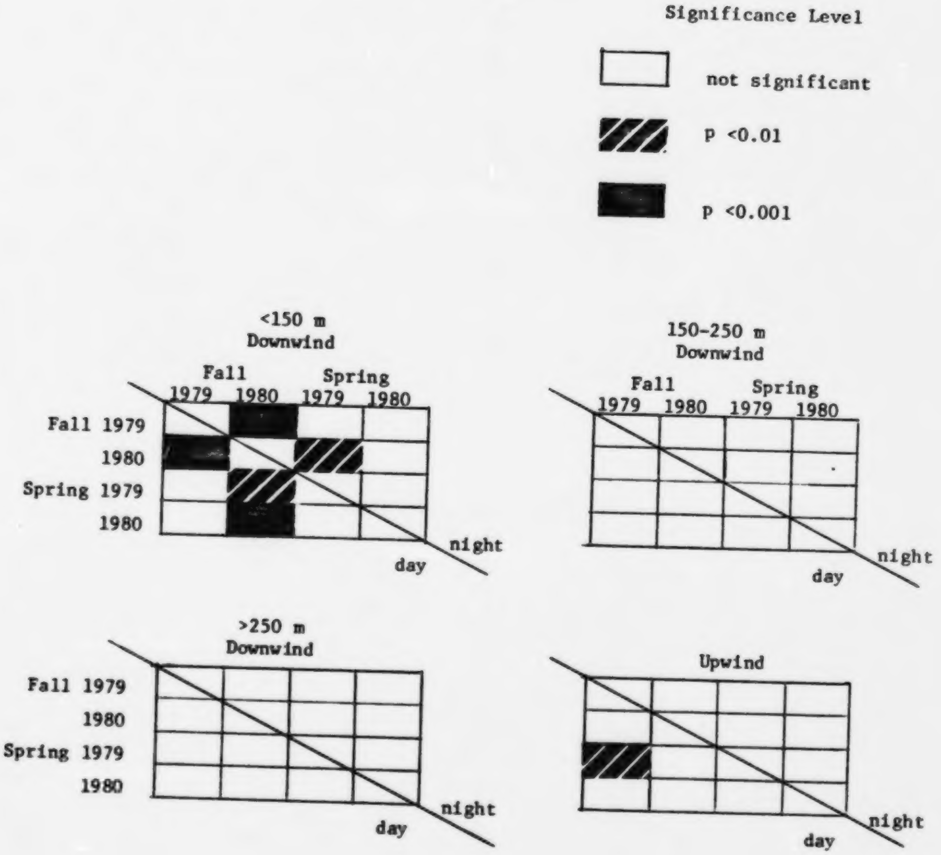

Figure 14. Significance of Andersen sampler total aerobic bacteria-containing particle differences by season.

bacteria were recovered by shielding the transparent slit sampler cover from sunlight, a study was performed to determine the effects of operating the samplers with and without light shields. The samples were collected with paired samplers, one of which was shielded with an aluminum foil cover. The sampling times were divided into two classifications: 30 min or less and 60 min. After each paired sample, the foil shield was removed from the first sampler and transferred to the second to eliminate potential sampler bias. After sampling, the plates were transported, incubated, and the colonies were counted, as described above. As shown in Table 2, the geometric mean concentration of the TABCP collected with uncovered slit samplers for sampling times of 30 min or less was 72 cfu/m^3 while that from the covered sampler was found to be 89 cfu/m^3. These differences were, however, not significant with a paired t test ($p > 0.05$). The data from similar studies performed with sampling periods of 60 min are presented in Table 3. The geometric mean from the uncovered samplers was 39 cfu/m^3, while that of the covered was 49 cfu/m^3. Although these differences were not significant with a paired t test ($p > 0.05$) the average concentration was lower than those from samples of 30 min or less duration.

Aerosol Particle Size

The aerodynamic size distributions of TABCP were determined during each sampling trial and are summarized by 1979 and 1980 season and by diurnal period in Tables 4 and 5. The overall aerosol count median diameter (CMD) was 3.3 to 4.7 µm, but some variability was observed by sampling location and season. At 150 to 250 m downwind, for example, the CMD was 3.3 to 4.7 µm in all nighttime and pre-plant operational daytime samples. During the spring/summer 1980 season, however, the CMD of daytime samples decreased to 2.1 to 3.3 µm, while in the fall 1980, the CMD of these daytime aerosols increased to 4.7 to 7 µm. Aerosols of 4.7 to 7 µm CMD were also observed at > 250 m downwind during the daytime of both fall sampling seasons, while they were found to be 2.1 to 3.3 µm CMD during the nighttime of the fall 1979 season.

The changes in TABCP aerosol particle size distribution after initiation of plant operations is illustrated in Figures 15, 16, 17, and 18. The ratio of the percent of aerosols in each of six size ranges during plant operations to that before operation for the fall daytime sampling periods is shown in Figure 15. At the first two downwind sampling locations aerosols of 0.65 to 3.3 µm were shown to decrease, while those in the 3.3 to 7.0 µm size range increased. Aerosols in the 1.1 to 2.2 µm size range increased substantially at > 250 m downwind as did the aerosols in the 4.7 to 7.0 µm size range at upwind locations. In general, the aerosol particle size at night increased at all sites during the fall of plant operations compared to that observed during the fall before plant operations. As shown in Figure 16, the greatest increase at all sites was observed in aerosols of the 3.3 to 4.7 µm size range. As shown in Figure 17, the aerosols in the 3.3 to 4.7 µm size range increased during the daytime of spring/summer plant operation at all four sampling locations. Although the proportion of aerosols in the 0.65 to 1.1 size range were found to be lower during plant operation at sites < 150 m downwind and upwind, these

TABLE 2. TOTAL AEROBIC BACTERIA-CONTAINING PARTICLES IN PAIRED COVERED AND UNCOVERED SLIT SAMPLERS

(Sample Duration $\leq$30 min.)

Uncovered	Covered
cfu/m^3	
224	72
27	88
43	106
81	62
99	83
144	71
59	71
71	24
130	148
32	32
18	61
73	169
29	179
102	32
51	283
268	154
86	158
157	162
89	254
88	116
49	121
62	83
53	55
92	29
$\overline{X}_G$ = 72	$\overline{X}_G$ = 89

TABLE 3. TOTAL AEROBIC BACTERIA-CONTAINING PARTICLES IN PAIRED COVERED AND UNCOVERED SLIT SAMPLERS

(Sample Duration 60 min.)

Uncovered	Covered
cfu/m^3	
45	35
58	50
21	35
48	68
84	87
130	96
40	39
44	65
35	54
29	36
47	54
53	70
34	26
41	58
50	57
51	45
16	18
40	72
7	47
$\overline{X}_G$ = 39	$\overline{X}_G$ = 49

TABLE 4. PERCENT TABCP PARTICLE SIZE DISTRIBUTION DURING FALL

Sampling Location[a] (m)	Plant Operation	Aerosol Particle Size (μm) 0.65-1.1	1.1-2.2	2.1-3.3	3.3-4.7	4.7-7.0	>7.0
Daytime							
Downwind							
<150	Before	9	13	16	16	19	27
	During	2	7	14	27	27	23
150-250	Before	12	12	15	18	15	28
	During	3	11	11	22	22	31
>250	Before	10	7	11	16	17	39
	During	6	12	11	16	19	36
Upwind	Before	9	22	15	23	13	18
	During	10	19	15	17	17	22
Nighttime							
Downwind							
<150	Before	7	17	14	16	22	24
	During	2	6	18	33	22	19
150-250	Before	14	12	15	15	14	30
	During	2	8	15	26	21	28
>250	Before	17	19	21	10	13	20
	During	7	4	11	30	20	28
Upwind	Before	12	10	15	18	19	26
	During	4	7	15	25	19	30

[a] With respect to center of aeration tanks; distances are downwind.

TABLE 5. PERCENT TABCP PARTICLE SIZE DISTRIBUTION DURING SPRING/SUMMER

Sampling Location[a] (m)	Plant Operation	Aerosol Particle Size (μm)					
		0.65-1.1	1.1-2.2	2.1-3.3	3.3-4.7	4.7-7.0	>7.0
Daytime							
Downwind <150	Before	16	8	22	13	25	16
	During	5	12	20	24	20	19
150-250	Before	6	19	17	18	18	22
	During	14	14	20	35	6	11
>250	Before	7	13	20	17	16	27
	During	6	11	21	21	19	22
Upwind	Before	18	15	17	13	19	18
	During	5	6	28	18	15	28
Nighttime							
Downwind <150	Before	15	16	18	19	15	17
	During	3	6	22	26	23	20
150-250	Before	11	16	9	15	14	35
	During	6	9	15	26	21	23
>250	Before	2	7	15	37	25	14
	During	3	14	15	23	16	29
Upwind	Before	15	16	12	16	21	20
	During	5	12	16	19	16	32

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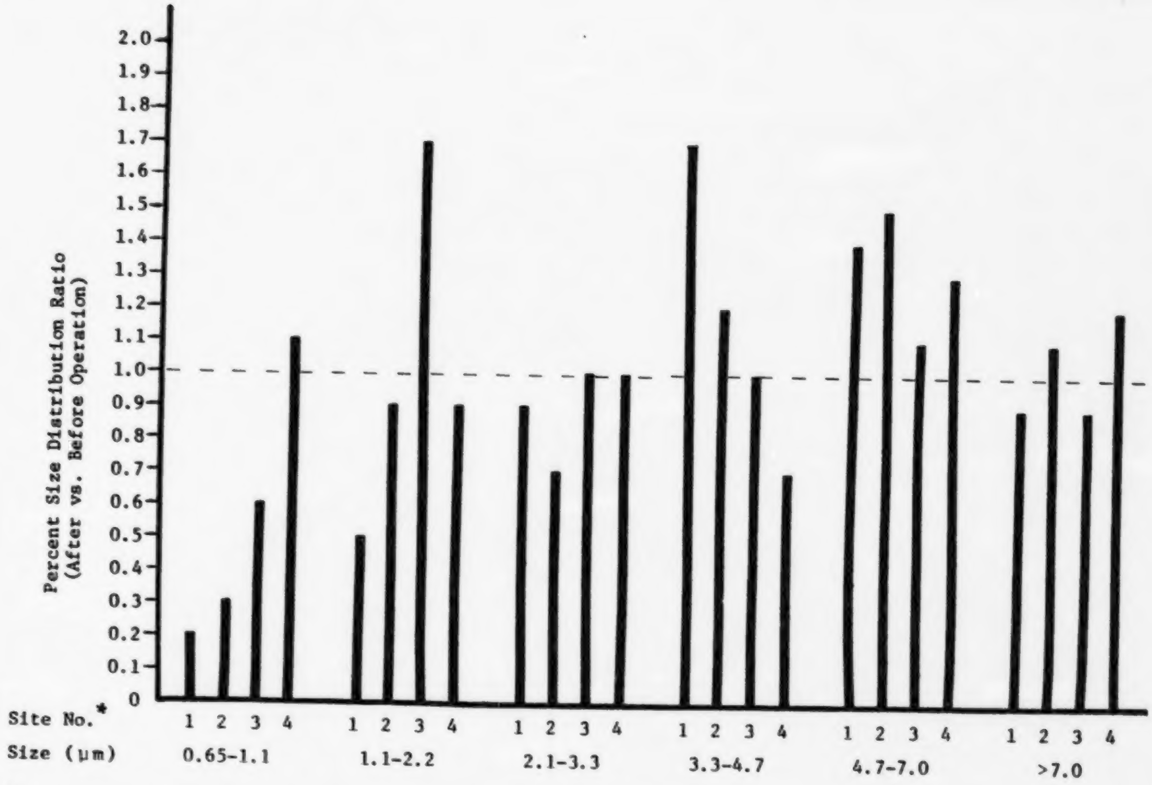
[a] With respect to center of aeration tanks; distances are downwind.



*Site No. 1 is <150 m, No. 2 is 150 to 250 m, and No. 3 is >250 m downwind from the center of the aeration tanks; site No. 4 is upwind.

Figure 15. TABCP aerosol percent size distribution ratio after versus before plant operations during fall daytime.

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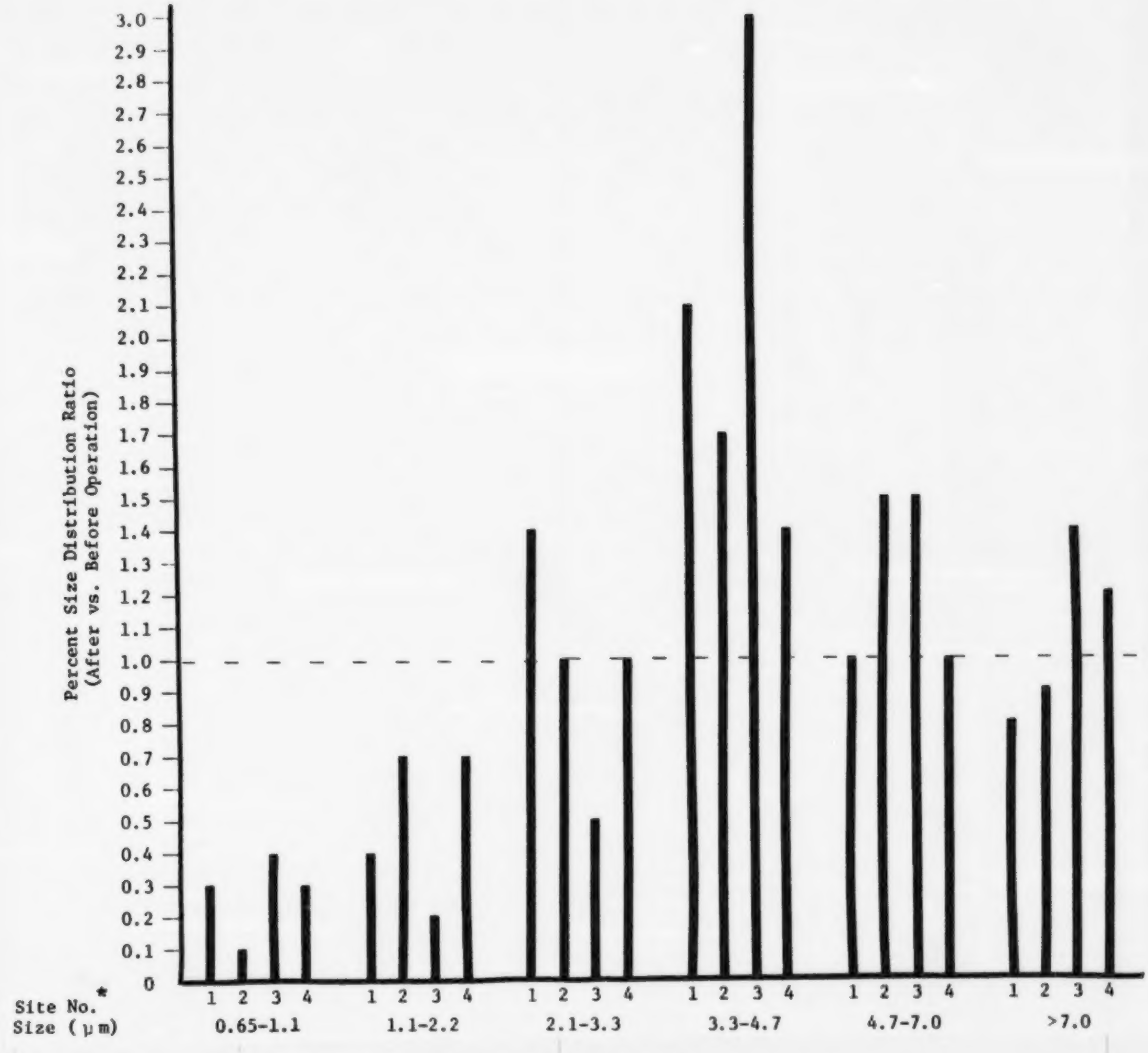

*Site No. 1 is <150 m, No. 2 is 150 to 250 m, and No. 3 is >250 m downwind from the center of the aeration tanks; Site No. 4 is upwind.

Figure 16. TABCP aerosol percent size distribution ratio after versus before plant operations during fall nighttime.

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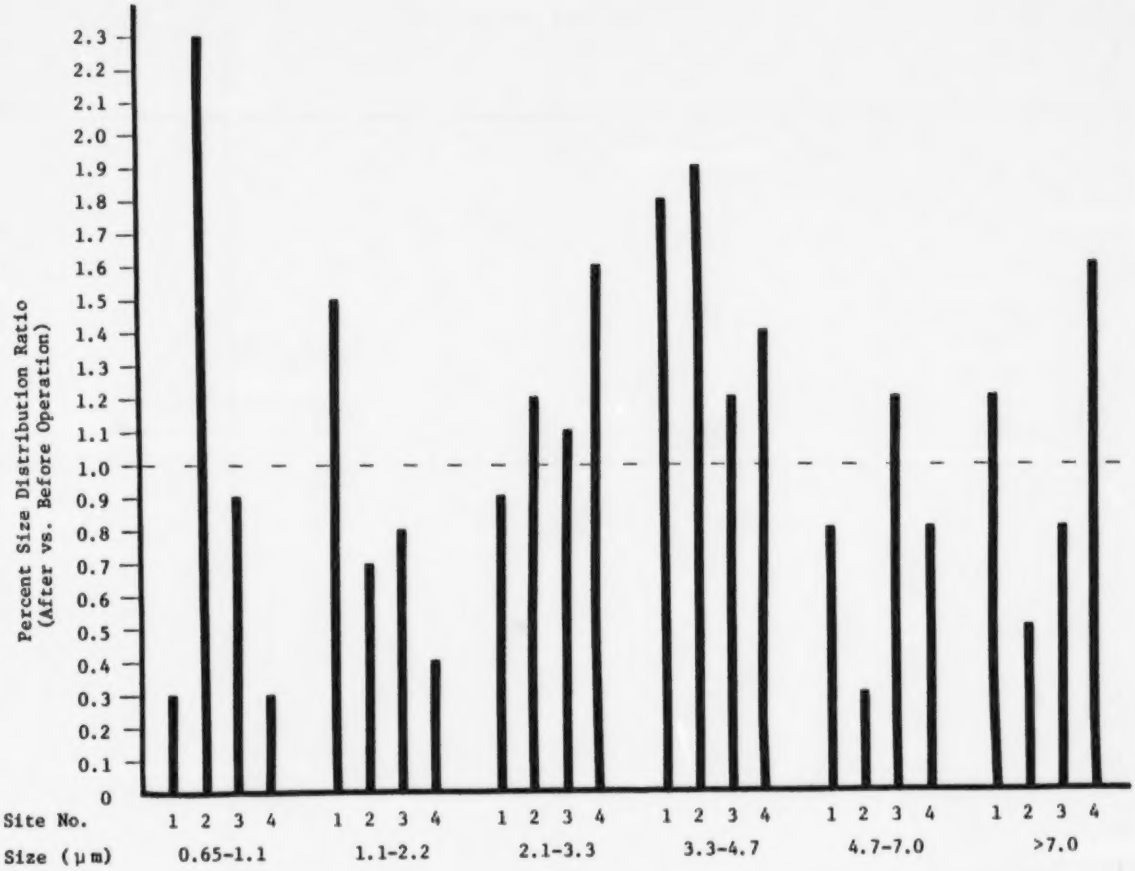
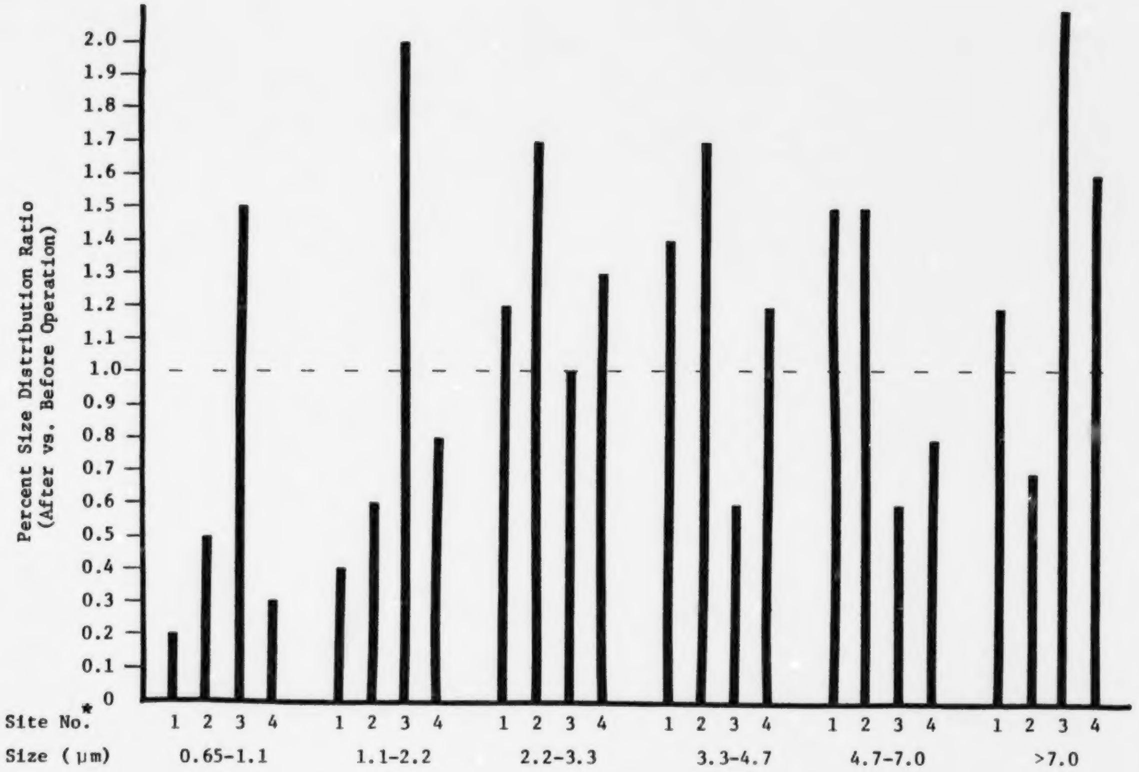


*Site No. 1 is < 150 m, No. 2 is 150 to 250 m, and No. 3 is >250 m downwind from the center of the aeration tanks; Site No. 4 is upwind.

Figure 17. TABCP aerosol percent size distribution ratio after versus before plant operations during spring/summer daytime.



*Site No. 1 is <150 m, No. 2 is 150 to 250 m, and No. 3 is >250 m downwind from the center of the aeration tanks; Site No. 4 is upwind.

Figure 13. TABCP aerosol percent size distribution ratio after versus before plant operations during spring/summer nighttime.

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these small aerosols increased substantially at 150 to 250 downwind and changed very little at > 250 m downwind. During the spring/summer night sampling periods, illustrated in Figure 18, the percent aerosols in the 0.65 to 1.1 µm size range decreased at all locations except at those locations that were > 250 m downwind, where they increased. The aerosols at < 150 m and 150 to 250 m downwind increased most substantially in the 2.1 to 7.0 µm size range, while those at locations >250 m downwind increased most substantially in the 0.65 to 2.2 and > 7.0 µm size range. The upwind aerosols increased in the 2.1 to 4.7 and in the > 7.0 µm size ranges.

STANDARD PLATE COUNT

The SPC aerosol concentration at < 150 m downwind from the center of the aeration tanks increased significantly ($p < 0.01$) after initiation of plant operations. Although increases were observed during plant operation in both day and nighttime spring/summer samples and during daytime fall samples, the most significant increase ($p < 0.001$) of 55 to 1325 cfu/m^3 (Table 6), was seen during fall nighttime sampling. Although the mean concentration at 150-250 m downwind during the spring 1979 daytime period was high, the only significant differences ($p < 0.01$) observed at this site were from the fall before and during plant operations during the nighttime. Significant ($p < 0.01$) increases were also observed during the fall sampling seasons at nighttime at the most distant downwind sampling site. The SPC concentration at this site increased after plant operations were initiated from 60 to 262 cfu/m^3 during the fall but only from 64 to 91 cfu/m^3 during the spring/summer. Although no significant differences in SPC organism concentrations were observed at the upwind location after the plant began operation, mean increases in concentration during plant operations were seen during the fall daytime and during the nighttime sampling periods of both seasons. During the fall, this mean concentration increased from 29 to 298 cfu/m^3 before and during plant operations, respectively.

TOTAL COLIFORM

The frequency of total coliform aerosol detection before plant operations, at downwind sampling locations, shown in Table 7, ranged from 38% to 52% of all countable samples while, during plant operations, this frequency ranged from 79% to 91% of all countable samples. At the upwind sampling location the frequency of total coliform detection ranged from 36% to 59% during and before plant operations, respectively. At < 150 m downwind from the center of the aeration tanks the weighted geometric mean aerosol concentration increased from 0.30 cfu/m^3 before to 5.03 cfu/m^3 during plant operations. At the 150 to 250 m downwind location the weighted geometric mean concentration was 0.15 cfu/m^3 before and 0.77 cfu/m^3 during plant operations. At > 250 m downwind the weighted geometric mean concentration was 0.14 cfu/m^3 and 0.62 cfu/m^3 before and during plant operations, respectively.

The fall nighttime concentration increases at sites < 150 m downwind were found to be the most highly significant ($p = 0.009$) of the seasonal diurnal sampling periods. At the 150 to 250 m downwind location, the total coliform aerosol concentration increased most significantly ($p = 0.004$) during the spring/ summer daytime sampling period. No significant increases in total

TABLE 6. STANDARD PLATE COUNT AEROSOLS IN PLANT VICINITY BEFORE AND DURING OPERATIONS

Sampling Location[a] (m)	Season	Geometric Mean (cfu/m^3)			
		Daytime		Nighttime	
		Before[b]	During	Before	During
Downwind					
<150	Spring/Summer	763	283	27	96
	Fall	49	220	55	1325**[c]
150-250	Spring/Summer	1100[d]	68	77	229
	Fall	32	102	65	410*
>250	Spring/Summer	301	56	64	91
	Fall	51	194	60	262*
Upwind	Spring/Summer	139	101	75	127
	Fall	43	157	29	297

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[a] With respect to center of aeration tanks; distances are downwind.

[b] Before or during plant operations.

[c] * and ** indicate significant at the $\alpha = 0.001$ and $\alpha = 0.01$ levels, respectively.

[d] This value skewed by a single sample with an observed large concentration (19,200 cfu/m^3).

TABLE 7. TOTAL COLIFORM AEROSOLS IN PLANT VICINITY BEFORE AND DURING OPERATIONS

Sampling Location[a] (m)	Frequency of Detection		Geometric Mean (cfu/m^3)			
	Before Operation (%)	During Operation (%)	Before Operations		During Operations	
			Positive Samples	Weighted	Positive Samples	Weighted
Downwind						
<150	12/23 (52)	20/22 (91)	0.57	0.30	5.53	5.03
150-250	14/28 (50)	23/27 (85)	0.30	0.15	0.90	0.77
>250	5/13 (38)	15/19 (79)	0.36	0.14	0.78	0.62
Upwind	13/22 (59)	8/22 (36)	0.33	0.20	0.50	0.18

[a] With respect to center of aeration tanks; distances are downwind.

coliform aerosols were observed at > 250 m downwind or at the upwind sampling locations.

Based on the total coliform aerosol concentrations summarized in Table 7 and presented in Appendix C, the significance of concentration differences before and during plant operations is shown in Table 8. This aerosol concentration increased significantly at < 150 m downwind from the center of the aeration tanks during both the daytime ($p < 0.01$) and nighttime ($p < 0.001$). Significant increases ($p < 0.01$) were observed at 150 to 250 m downwind during the nighttime but not during the daytime. Significant concentration increases were observed at nighttime during both the fall and spring/summer seasons. Although significant increases were observed during these seasons at nighttime, total coliform aerosol concentrations were generally higher during the daytime.

The total coliform aerosol concentrations during each pre- and post-plant operation sampling season was compared and significant differences are illustrated in Figure 19. Significant concentration differences ($p < 0.01$), observed only at the first two downwind locations, occurred only between pre- and post-plant operations seasons. That is, there was no significant total coliform aerosol concentration difference between the spring and fall before plant operations or between spring/summer and fall during plant operations. There was no significant concentration increases during the fall before and during operations at 150 to 250 m downwind of the aeration tank center.

FECAL COLIFORM

While fecal coliform bacteria-containing aerosols were detected at each sampling site before plant operations were initiated (Table 9) the frequency of detection increased at each location during plant operations. The weighted downwind fecal coliforms geometric mean concentration before plant operations ranged from 0.12 cfu/m^3 at the < 150 m location to 0.21 cfu/m^3 at the 150 to 250 m downwind location. Both the frequency of fecal coliform detection and geometric mean concentration at all downwind sites exceeded that of the upwind site and suggest that the preoperational plant grounds was a source of low-level fecal coliform aerosols.

After plant operations were initiated, the frequency of fecal coliform aerosol detection at < 150 m downwind of the center of the aeration tanks increased from 22% to 82% of the countable samples and the weighted geometric mean concentration increased from 0.12 to 1.02 cfu/m^3. The frequency of detection at the 150 to 250 m downwind location increased from 21% to 59% of the countable samples but the weighted geometric mean aerosol concentration remained relatively unchanged. At the > 250 m downwind location the frequency of detection also increased during plant operations, from 0% to 63% of the countable samples and the weighted geometric mean was 0.13 cfu/m^3 after operations started. Although the frequency of fecal coliform detection at the upwind location increased from 5% to 22% of the countable samples, the weighted geometric mean concentration during plant operations was found to be 0.02 cfu/m^3 compared to 0.00 cfu/m^3 before operations started.

TABLE 8. SIGNIFICANCE[a] OF TOTAL COLIFORM AEROSOL DIFFERENCES IN PLANT VICINITY BEFORE AND DURING OPERATIONS

Sampling Location[b] (m)	Total	Daytime	Nighttime
Downwind			
<150	<0.001	<0.01	<0.001
150-250	<0.001	c	<0.01
>250	c	c	c
Upwind	c	c	c

[a] H_0 that concentrations during operations did not exceed those before operations is rejected at indicated significance level with the Mann-Whitney U test.

[b] With respect to center of aeration tanks; distances are downwind.

[c] H_0 that concentrations during operations did not significantly exceed those observed before operations began is not rejected at the $\alpha = 0.01$ level.

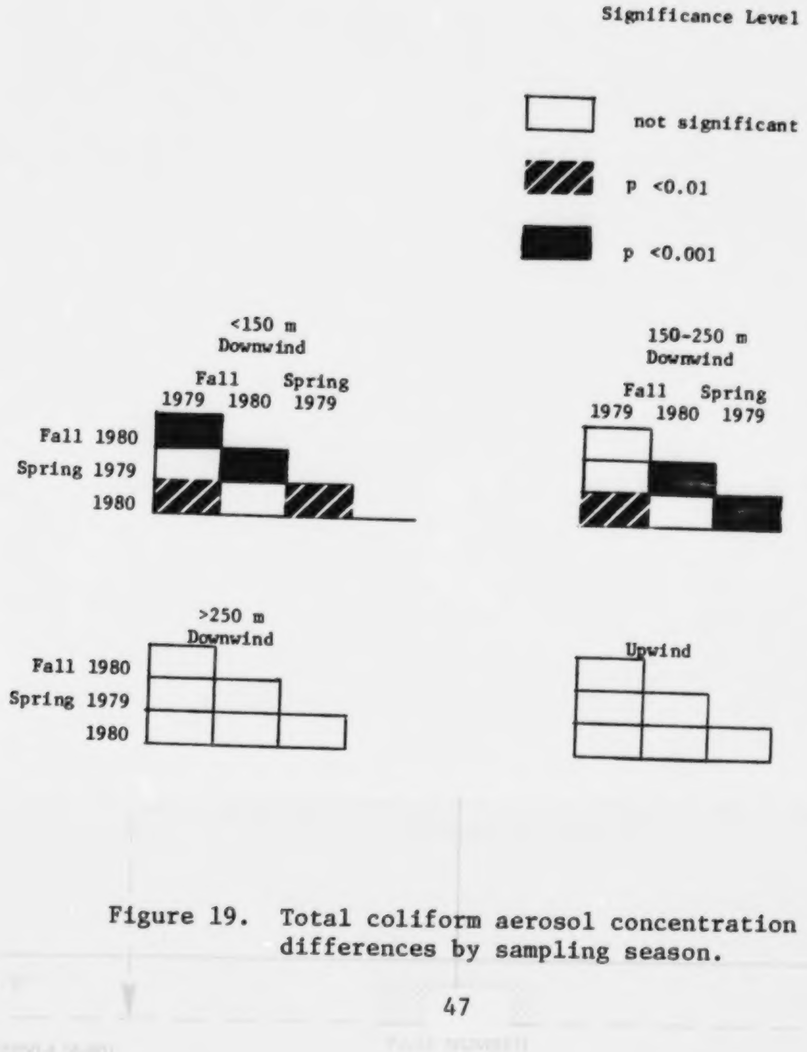

Figure 19. Total coliform aerosol concentration differences by sampling season.

TABLE 9. FECAL COLIFORM AEROSOLS IN PLANT VICINITY BEFORE AND DURING OPERATIONS

Sampling Location[a] (m)	Frequency of Detection		Geometric Mean (cfu/m^3)			
	Before Operation (%)	During Operation (%)	Before Operation		During Operation	
			Positive Samples	Weighted	Positive Samples	Weighted
Downwind						
<150	5/23 (22)	18/22 (82)	0.57	0.12	1.25	1.02
150-250	6/28 (21)	16/27 (89)	0.99	0.21	0.41	0.24
>250	0/13 (0)	12/19 (63)	0.00	0.00	0.21	0.13
Upwind	1/22 (5)	5/23 (22)	0.10	0.00	0.07	0.02

[a] With respect to center of the aeration tanks; distances are downwind.

Fecal coliform aerosol concentrations increased significantly ($p < 0.01$) during plant operations within 150 m downwind of the center of the aeration tanks. As shown in Table 10, the most significant differences ($p < 0.001$) were observed at this first downwind site when both day- and nighttime samples were combined. Significant concentration increases ($p < 0.01$) were also seen at the 150 to 250 m downwind distance in the combined but not in the day- or nighttime-specific samples. The frequency of positive observations during plant operations at > 250 m downwind increased from 0% to 63% and, although the analysis employed required at least 3 positive observations in each category, appeared to be highly significant. No significant differences were observed at the upwind sampling sites between the fecal coliform concentrations seen before and after plant operations.

FECAL STREPTOCOCCUS

Fecal streptococcus-containing aerosols, as shown in Table 11, were detected in 57% to 69% of all downwind and upwind countable samples before plant operations started. During plant operations, these aerosols were detected in 89% to 91% of the countable downwind samples and in 82% of the countable upwind samples. The weighted geometric mean aerosol concentration before and during plant operations, respectively, was 0.14 and 0.66 cfu/m^3 at < 150 m, 0.18 and 0.44 cfu/m^3 at 150 to 250 m, and 0.22 and 0.57 cfu/m^3 at > 250 m downwind from the center of the aeration tanks. The upwind concentration before and during plant operation was 0.20 and 0.28 cfu/m^3, respectively. The fecal streptococci concentration increased significantly ($p < 0.001$) within 150 m downwind of the aeration tanks after plant operations were started (Table 12). Although these increases were significant ($p < 0.01$) during both the nighttime and daytime, the observed daytime concentrations were significantly ($p < 0.01$) higher during plant operations than before such operations were initiated. These significant increases were, however, only observed during the nighttime. No significant concentration differences were seen in the samples, not specified by season, taken at either the > 250 m downwind or upwind sampling locations.

When observing the seasonal-specific data, Figure 20, highly significant concentration increases ($p < 0.001$) were observed at the < 150 m downwind sampling site between the spring before operations and both the spring and fall during operations. Although the highest fecal streptococus aerosol concentration was observed at this site during the fall of plant operation, these observations were not found to be significantly higher than those observed before plant operations began. At the 150 to 250 m downwind location, significant ($p < 0.01$) concentration increases were also observed from spring before operations to both the spring and fall during operations but, again, no significant concentration increases over those seen during the fall before operations were observed. Significant fecal streptococcus concentration differences were seen at both the > 250 m downwind and the upwind locations between those observed during spring and fall before operations and between the spring before and after operations.

TABLE 10. SIGNIFICANCE[a] OF FECAL COLIFORM AEROSOL DIFFERENCES IN PLANT VICINITY BEFORE AND DURING PLANT OPERATIONS

Sampling Location[b]	Total	Daytime	Nighttime
Downwind			
<150	0.001	0.01	0.01
150-250	0.01	c	c
>250	d	d	d
Upwind	c	c	c

[a] H_0 that concentrations during operations did not exceed those before operations is rejected at indicated significance level with the Mann-Whitney U test.

[b] With respect to center of aeration tanks; distances are downwind.

[c] H_0 that concentrations during operation did not significantly exceed those observed before operations began is not rejected at the $\alpha = 0.01$ level.

[d] Statistical analyses not done because no samples were positive before plant operations began.

TABLE 11. FECAL STREPTOCOCCUS AEROSOLS IN PLANT VICINITY BEFORE AND DURING OPERATIONS

Sampling Location[a] (m)	Frequency of Detection Before Operation (%)	Frequency of Detection During Operation (%)	Geometric Mean (cfu/m^3) Before Operation Positive Samples	Before Operation Weighted	During Operation Positive Samples	During Operation Weighted
Downwind						
<150	13/23 (57)	21/23 (91)	0.24	0.14	0.72	0.66
150-250	18/28 (64)	24/27 (89)	0.28	0.18	0.49	0.44
>250	9/13 (69)	17/19 (89)	0.32	0.22	0.64	0.57
Upwind	13/22 (59)	18/22 (82)	0.33	0.20	0.34	0.28

[a] With respect to center of aeration tanks; distances are downwind.

TABLE 12. SIGNIFICANCE[a] OF FECAL STREPTOCOCCUS AEROSOL DIFFERENCES IN PLANT VICINITY BEFORE AND DURING OPERATIONS

Sampling Location[a] (m)	Total	Daytime	Nighttime
Downwind			
< 150	<0.001	<0.01	<0.01
150-250	<0.01	c	<0.01
> 250	c	c	c
Upwind	c	c	c

---

[a] H_O that concentrations during operations did not exceed those before operations is rejected at indicated significance level with the Mann-Whitney U test.

[b] With respect to center of aeration tanks; distances are downwind.

[c] H_O that concentrations during operations did not significantly exceed those observed before operations began is not rejected at the $\alpha = 0.01$ level.

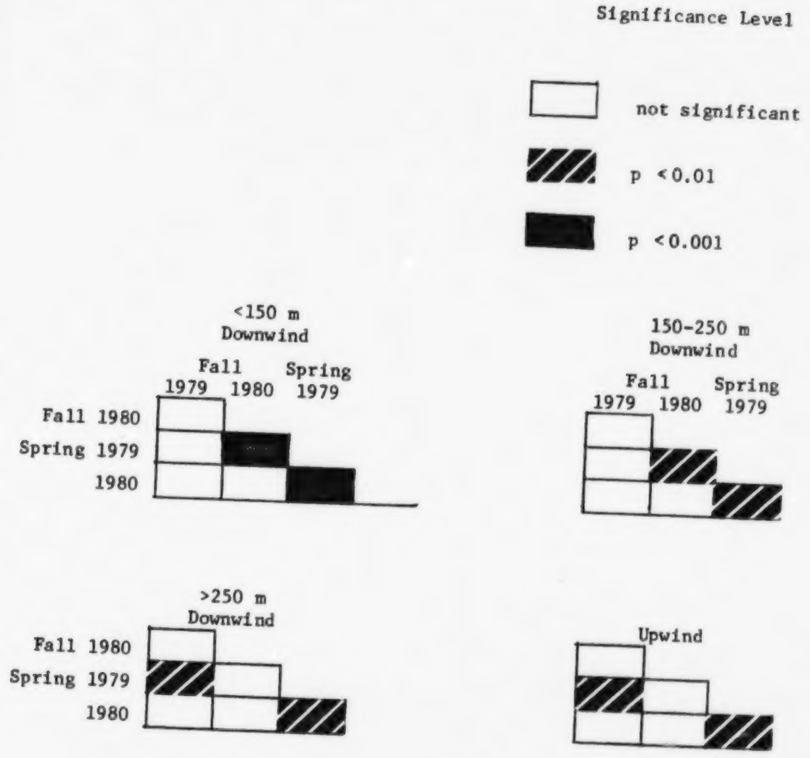

Figure 20. Fecal streptococcus aerosol concentration differences by sampling season.

BACTERIAL IDENTIFICATION

The bacterial aerosol isolates identified from total coliform colonies before and after plant operations were initiated are identified in Tables 13 and 14, respectively. Before plant operations, bacteria were detected from the genera *Klebsiella*, *Enterobacter*, *Escherichia*, *Serratia*, *Aeromonas*, and *Pseudomonas*. During plant operations, these genera were all detected from aerosols and additional genera, including *Salmonella*, *Providencia*, *Citrobacter*, *Acinetobacter*, *Pasteurella*, and *Proteus*, were also detected.

Before plant operations were started, the genus *Enterobacter* was most frequently detected, with *E. agglomerans* as the most frequently identified organism with 32, 10, and 2, isolates from sites <150 m, 150 to 250 m, and > 150 m downwind, respectively and 19 isolates from upwind sites. *Klebsiella pneumoniae* was detected once at > 250 m downwind from one pre-plant operation daytime sample. Another *Klebsiella* sp. was also detected during the daytime at > 250 m downwind, while *K. ozaenae* and *oxytoca* were detected two and one times, respectively, at thw upwind sites. Three *Salmonella* species isolates (2 *S. paratyphi* and 1 *S.* sp.) were detected within 250 m downwind of the plant.

During plant operations, the most frequently isolated genera were *Escherichia* followed by *Enterobacter*, *Klebsiella*, and *Citrobacter*. Most of these isolates were found in aerosols < 150 m downwind of the center of the aeration tanks and 93% or more of the *Klebsiella* and *Escherichia* sp. and 81% of the *Enterobacter* isolates were detected at locations closer than 250 m during either daytime and nighttime samples. The most frequently isolated *Klebsiella* species was *K. oxytoca* (52) followed by *K. pneumonia* (44). The higher frequency of species identification during the daytime than at nighttime reflects a greater number to total coliform isolates during this period.

SALMONELLA SP.

Salmonella sp.-containing aerosols were detected using DSE broth on only one occasion during the study period. As shown in Table 15, one *Salmonella* sp. isolate was confirmed as *S. cholerae* within 150 m downwind of the center of the aeration tanks before the plant became operational and none was confirmed at any site during plant operations (Table 16). Using m-Endo broth and API 20E strips, as shown in Table 14, however, *Salmonella* sp. aerosols were confirmed on two occasions at < 150 m and on one occasion at 150 to 250 m downwind of the center of the aeration tanks. No *Salmonella* sp. aerosols were detected using m-Endo broth before the plant began operations.

COLIPHAGES

Aerosol concentrations of *E. coli* C3000 coliphages for day- and nighttime samples are shown in Tables 17 and 18 for observations made before and during plant operations, respectively. Before plant operations, aerosols of *E. coli* C3000 coliphages were detected on three of eleven occasions. As shown in Table 17, when such coliphages were detected, their aerosol concentrations ranged from 1.02 to 0.14 mpnpfu/m^3 at nighttime and from 0.02 to 0.21 mpnpfu/m^3 during the daytime and were detected on at least one occasion at each site. After plant operations were initiated, the frequency of coliphage

TABLE 13. BACTERIA IDENTIFIED IN AEROSOLS IN PLANT VICINITY BEFORE OPERATIONS

Sampling Location (m)	Downwind <150 m Day/Night	Downwind 150-250 m Day/Night	Downwind >250 m Day/Night	Upwind Day/Night
Klebsiella				
sp.	--	--	1/0	--
oxytoca	--	--	--	0/2
ozaenae	--	--	--	0/1
pneumoniae	--	--	1/0	--
Enterobacter				
agglomerans	29/3	10/0	1/1	11/8
cloacae	1/2	0/4	--	5/4
sakazakii	1/0	0/1	--	--
sp.	--	0/1	--	--
Escherichia				
coli	2/0	--	--	1/0
Serratia				
sp.	0/2	--	--	--
marcescens	0/1	--	--	--
Aeromonas				
hydrophila	2/1	--	--	--
Pseudomonas				
sp.	7/0	--	--	--
API Group 2	--	1/0	--	--
Totals	42/9	11/6	3/1	17/15

TABLE 14. BACTERIA IDENTIFIED IN AEROSOLS IN PLANT VICINITY DURING OPERATIONS

Sampling Location (m)	Downwind <150 m Day/Night	Downwind 150-250 m Day/Night	Downwind >250 m Day/Night	Upwind Day/Night
Klebsiella				
sp.	3/2	--	--	--
oxytoca	27/13	6/3	0/2	1/0
ozaenae	0/1	--	--	--
pneumoniae	20/15	6/1	3/1	--
Salmonella				
sp.	0/1	--	--	--
paratyphi A	1/0	0/1	--	--
Enterobacter				
agglomerans	3/4	3/1	3/0	6/0
aerogenes	2/0	1/1	--	0/1
cloacae	60/18	22/17	8/6	3/0
sakazakii	2/0	1/0	0/1	1/0
Escherichia				
coli	55/64	29/32	6/0	0/1
Serratia				
sp.	1/0	--	--	--
liquefaciens	4/2	0/3	--	--
odoriferal	0/1	1/0	--	--
rubideae	--	--	--	1/0
Providencia				
alcalifaciens	0/1	--	--	--
rettgeri	1/0	--	--	--
Aeromonas				
hydrophila	4/1	1/1	--	--

(Continued)

TABLE 14 CONTINUED

Sampling Location (m)	Downwind <150 m Day/Night	Downwind 150-250 m Day/Night	Downwind >250 m Day/Night	Upwind Day/Night
Pseudomonas sp.	0/1	--	1/0	--
Citrobacter freundi	22/11	8/10	2/1	1/1
Acinetobacter calcoaceticus	1/2	0/1	1/0	--
Pasteurella multocida	--	0/1	--	--
Proteus vulgaris	0/1	--	--	--
CDC Group SEI	--	--	--	1/0
Totals	206/138	78/72	24/11	14/3

TABLE 15. SALMONELLA SP. AEROSOLS IN PLANT VICINITY BEFORE OPERATIONS

Date	Sampling Location[a]	Air Vol. Assayed m^3	Salmonella sp. Positive Tubes, % of total	mpnvu/m^3
Daytime				
6/14/79	1A	41	0	0.00
	1B	41	0	0.00
	4	41	0	0.00
10/8/79	1	43	1[b]	0.02
	2	40	0	0.00
	3	30	0	0.00
	4	37	0	0.00
10/24/79	1	37	0	0.00
	2A	40	0	0.00
	2B	49	0	0.00
	4	34	0	0.00
Nighttime				
4/20/79	1	41	0	0.00
	2	41	0	0.00
	3	31	0	0.00
	4	41	0	0.00
5/2/79	1	29	0	0.00
	2A	31	0	0.00
	2B	41	0	0.00
	4	41	0	0.00
5/15/79	1	43	0	0.00
	2	40	0	0.00
	3	31	0	0.00
	4	47	0	0.00
8/23/79	1	35	0	0.00
	2	40	0	0.00
	3	43	0	0.00
	4	43	0	0.00
9/12/79	1	42	0	0.00
	2	37	0	0.00
	3	41	0	0.00
	4	43	0	0.00
10/30/79	1	39	0	0.00
	2	34	0	0.00
	3	40	0	0.00
	4	43	0	0.00

[a] Sampling sites located with respect to center of aeration tanks as follows: Downwind: (1) < 150 m; (2) 150-250 m; (3) >250 m; Upwind (4).

[b] *Salmonella cholerae*.

TABLE 16. SALMONELLA SP. AEROSOLS IN PLANT VICINITY DURING OPERATIONS

Date	Sampling Location[a]	Air Vol. Assayed m^3	Salmonella sp. Positive Tubes, % of Total	mpnvu/m^3
Daytime				
6/26/80	1	28	0	0.00[b]
	2	33	0	0.00
	3	40	0	0.00
	4	32	0	0.00
7/23/80	1	28	0	0.00
	3	40	0	0.00
	4	32	0	0.00
8/5/80	1	34	0	0.00
	2	28	0	0.00
	3	32	0	0.00
	4	38	0	0.00
9/5/80	1	32	0	0.00
	2	28	0	0.00
	3	36	0	0.00
	4	38	0	0.00
10/31/80	1	28	0	0.00
	2	34	0	0.00
	3	32	0	0.00
	4	38	0	0.00
11/10/80	1	28	0	0.00
	2	32	0	0.00
	3	34	0	0.00
	4	38	0	0.00
Nighttime				
7/7/80	1	40	0	0.00
	2	28	0	0.00
	3	34	0	0.00
	4	32	0	0.00
8/15/80	1	28	0	0.00
	2	32	0	0.00
	3	35	0	0.00
	4	38	0	0.00

(Continued)

TABLE 16, CONTINUED

Date	Sampling Location[a]	Air Vol. Assayed m^3	Salmonella sp. Positive Tubes, % of Total	mpnvu/m^3
Nighttime				
9/11/80	1	38	0	0.00[c]
	2	33	0	0.00
	3	28	0	0.00
	4	34	0	0.00
9/24/80	1	28	0	0.00
	2	32	0	0.00
	3	35	0	0.00
	4	38	0	0.00
10/7/80	1	32	0	0.00
	2	34	0	0.00
	3	28	0	0.00
	4	38	0	0.00
10/20/80	1	38	0	0.00
	2A	34	0	0.00
	2B	28	0	0.00
	4	32	0	0.00

[a] Sampling sites located with respect to center of aeration tanks as follows: Downwind: (1) <150 m; (2)<150-250 m; (3) >250 m; Upwind (4).

[b] Salmonella paratyphi A was identified from one total coliform cfu in a separate sample on 6/26 at Site 1 and 8/21 at Site 2.

[c] Salmonella sp. was identified from one total coliform cfu in a separate sample.

TABLE 17. COLIPHAGE AEROSOLS IN PLANT VICINITY BEFORE OPERATION

Date	Sampling Location[a]	Air Vol. Assayed m^3	Coliphages: Positive Tubes, % of total	Coliphages: mpnpfu/m^3
Daytime				
4/16/79	1	41	0	0.00
	2	44	0	0.00
	3	37	0	0.00
	4	31	0	0.00
5/10/79	1A	41	0	0.00
	1B	41	0	0.00
	2	32	0	0.00
	4	39	0	0.00
5/22/79	1	41	3	0.02
	2	41	3	0.02
	3	26	15	0.21
	4	39	6	0.05
10/11/79	1	37	0	0.00
	2	43	0	0.00
	3	34	0	0.00
	4	43	0	0.00
11/7/79	1	39	0	0.00
	2	34	0	0.00
	3	40	0	0.00
	4	43	0	0.00
Nighttime				
10/6/78	2	61	0	0.00
	3	61	0	0.00
4/28/79	1	41	0	0.00
	2A	41	0	0.00
	2B	41	0	0.00
	4	31	0	0.00
6/6/79	1	26	0	0.00
	2	45	0	0.00
	3	41	0	0.00
	4	41	12	0.10
6/11/79	1	41	0	0.00
	2	41	0	0.00
	3	27	0	0.00
	4	41	0	0.00

(Continued)

TABLE 17, CONTINUED

Date	Sampling Location[a]	Air Vol. Assayed m^3	Coliphages Positive Tubes, % of total	Coliphages mpnpfu/m^3
Nighttime				
9/4/79	1	43	3	0.02
	2	40	0	0.00
	3	40	15	0.14
	4	37	0	0.00
9/24/79	1	37	0	0.00
	2	43	0	0.00
	3	40	0	0.00
	4	43	0	0.00

[a] Sampling sites located with respect to center of aeration tanks as follows: Downwind: (1) <150 m; (2) 150-250 m; (3) >250 m; Upwind (4).

TABLE 18. COLIPHAGE AEROSOLS IN PLANT VICINITY DURING OPERATIONS

Date	Sampling Location[a]	Air Vol. Assayed m^3	Coliphages Positive Tubes % of Total	 mpnpfu/m^3
Daytime				
5/19/80	1	43	3	0.02
	2	37	0	0.00
	3	21	0	0.00
	4	40	0	0.00
7/28/80	1	40	26	0.26
	2A	28	0	0.00
	2B	32	0	0.00
	4	34	0	0.00
9/3/80	1	32	6	0.06
	2	28	6	0.07
	3	34	48	0.38
	4	38	0	0.00
9/29/80	1	28	0	0.00
	2	38	3	0.03
	3	32	6	0.06
	4	34	3	0.03
11/5/80	1	28	6	0.07
	2	34	0	0.00
	3	32	6	0.06
	4	38	0	0.00
11/12/80	1	34	6	0.06
	2A	32	3	0.03
	2B	28	0	0.00
	4	38	0	0.00
Nighttime				
7/11/80	1	40	21	0.19
	2	31	3	0.03
	3	28	15	0.19
	4	34	0	0.00

(Continued)

TABLE 18. CONTINUED

Date	Sampling Location[a]	Air Vol. Assayed m^3	Coliphages Positive Tubes % of Total	Coliphages mpnpfu/m^3
Nighttime				
8/12/80	1	28	24	0.32
	2	37	21	0.21
	3	32	6	0.06
	4	34	3	0.03
10/10/80	1	38	12	0.11
	2	34	9	0.09
	3	28	12	0.15
	4	32	0	0.00
10/24/80	1	34	18	0.19
	2A	32	12	0.13
	2B	39	3	0.03
	4	28	3	0.04

[a] Sampling sites located with respect to center of aeration tanks as follows: Downwind: (1) <150 m; (2) 150-250 m; (3) >250 m; Upwind (4).

aerosol detection increased substantially and they were found during each sampling occasion.

Table 18 shows that coliphage aerosol concentrations were higher at night than during the day. Daytime coliphage concentrations expressed as mpnpfu/m^3 ranged from 0.00 to 0.26 at sites < 150 m downwind, 0.00 to 0.07 at sites 150 to 250 m downwind, 0.00 to 0.38 at sites > 250 m downwind, and 0.00 to 0.03 at upwind sites. The nighttime concentrations, also expressed as mpnpfu/m^3, ranged from 0.11 to 0.32 at sites < 150 m downwind, 0.03 to 0.21 at sites 150 to 250 m downwind, 0.06 to 0.19 at sites > 250 m downwind, and 0.00 to 0.04 at upwind sites.

The frequency of coliphage detection during plant operations increased at all sampling locations over that observed before such operations started. As shown in Table 19, the frequency of detection increased from 18% to 90%, 8% to 62%, and 22% to 86%, at the <150 m, 150 to 250 m, and >250 m downwind sites, and from 20% to 30% at the upwind sites, respectively. The highest adjusted geometric mean concentration increases from 0.004 to 0.095 mpnpfu/m^3, were observed < 150 m downwind from the center of the aeration tanks. This concentration during plant operations at > 250 m downwind was 0.099 mpnpfu/m^3, suggesting that the coliphage aerosols remained viable to this most distant downwind location. Differences were significant at all these downwind locations.

ANIMAL VIRUS AEROSOLS

No animal viruses were detected using either BGM or WI-38 cells at either the upwind or downwind sites in the plant vicinity prior to initiating operations. As shown in Table 20, daylight and nighttime samples were taken on seven occasions each. The amount of air sample represented by each daylight downwind assay ranged from 245 m^3 to 602 m^3 while that volume from similar nighttime samples ranged from 128 m^3 to 720 m^3.

Similar studies conducted after the initiation of plant operations showed that animal viruses were detected on 2 of 12 occasions. As shown in Table 21, no viruses were detected during the daytime in either cell line from total downwind assay volumes volumes ranging from 385 to 428 m^3. While no viruses were detected at nighttime from upwind locations with either cell line, viruses were detected in BGM cells at the downwind location on 8/18 and 9/19/80 from assay volumes of 211 and 193 m^3, respectively. When detected, the BGM-determined animal virus concentration ranged from 4.7 X 10^{-3} to 1.0 X 10^{-2} cytopathic units (CPU) per m^3 of air. Although the single virus isolate detected on 8/18 was not identified with the Lim-Benyesh Melnick antisera pool, the two viruses from the 9/19 date were both identified as coxsackievirus B-1. The general wind direction on both occasions was from the south at approximately 4 to 5 m/sec.

ENVIRONMENTAL AND METEOROLOGICAL CONDITIONS

Sewage Flow

The sewage flow rate through this 272520 m^3/d (72 MGD) plant during the study period on each sampling date is shown in Appendix B and ranged from 56100 to 183200 m^3/d (14.8 to 48.4 MGD). During plant operations, as shown in

Table 19. COLIPHAGE AEROSOLS IN PLANT VICINITY BEFORE AND DURING OPERATIONS

Sampling Location[a] (m)	Frequency of Detection				Concentration, mpn pfu/m^3			
					Before Operation		During Operation	
	Before Operation	%	During Operation	%	Positive Samples	Weighted	Positive Samples	Weighted
Downwind								
< 150	2/11	18	9/10	90	0.02	0.004	0.11	0.095[b]**
150-250	1/12	8	8/13	62	0.02	0.002	0.05	0.030*
>250	2/9	22	6/7	86	0.17	0.038	0.12	0.099*
Upwind	2/10	20	3/10	30	0.07	0.014	0.03	0.010

[a] With respect to center of aeration tanks; distances are downwind.

[b] **Significant differences at $\alpha = 0.01$ and $\alpha = 0.001$ indicated by * and **, respectively.

TABLE 20. ANIMAL VIRUS AEROSOLS IN PLANT VICINITY BEFORE OPERATIONS

Date	Sampling Location[a]	BGM Cells Air Vol. Assayed m^3	BGM Cells Viruses Detected	WI-38 Cells Air Vol. Assayed m^3	WI-38 Cells Viruses Detected
Daytime					
10/14/78	2[b]	188	0	170	0
	4[b]	322	0	289	0
4/12/79	1	214	0	214	0
	4	209	0	218	0
5/7/79	1	252	0	252	0
	4	286	0	289	0
5/30/79	1	237	0	237	0
	4	278	0	298	0
8/15/79	1	298	0	304	0
	4	270	0	250	0
10/2/79	1	267	0	285	0
	4	270	0	277	0
10/22/79	1	120	0	125	0
	4	140	0	129	0
Nighttime					
10/18/78	1	387	0	333	0
	4	362	0	362	0
4/24/78	2	64	0	64	0
	4	66	0	63	0
5/18/79	1	232	0	234	0
	4	288	0	288	0
6/3/79	1	289	0	289	0
	4	234	0	240	0
9/8/79	1	270	0	249	0
	4	269	0	274	0
9/29/79	1	262	0	273	0
	4	297	0	258	0
10/18/79	1	234	0	258	0
	4	286	0	292	0

[a] Sampling sites located with respect to center of aeration tanks as follows: <150 m downwind (1); 150-250 m (2); upwind (4).

[b] These samples taken with LVAS electrostatic precipitator samplers. All other samples taken with LVS cyclone scrubber samplers.

TABLE 21. ANIMAL VIRUS AEROSOLS IN PLANT VICINITY DURING OPERATIONS

Date	Sampling Location[a]	BGM Cells		WI-38 Cells	
		Air Vol. Assayed m^3	Viruses Detected	Air Vol. Assayed m^3	Viruses Detected
		Daytime			
8/1/80	1	181	0	221	0
	4	227	0	232	0
8/26/80	1	186	0	207	0
	4	228	0	220	0
9/23/80	1	190	0	195	0
	4	235	0	238	0
10/2/80	1	219	0	209	0
	4	205	0	218	0
10/17/80	1	195	0	218	0
	4	198	0	211	0
10/28/80	1	213	0	192	0
	4	186	0	211	0
11/3/80	1	192	0	225	0
	4	181	0	233	0
		Nighttime			
6/19/80	1	202	0	208	0
	4	209	0	153	0
7/16/80	1	211	0	223	0
	4	238	0	209	0
8/18/80	1	211	1[b]	224	0
	4	220	0	219	0
9/8/80	1	213	0	228	0
	4	224	0	219	0
9/19/80	1	193	2[c]	218	0
	4	212	0	205	0

[a] Sampling sites located with respect to center of aeration tanks as follows: <150 m downwind (1); upwind (4).

[b] Virus isolate not identified with enterovirus anti-sera pool.

[c] Two isolates: both identified as coxsackievirus B-1.

Table 22, total aerobic bacteria-containing particle concentrations determined with slit samplers increased ($p < 0.005$) with the sewage flow rate during the fall and during the fall and spring/summer at both the < 150 m and the 150 to 250 m downwind sampling locations. While there was a positive correlation with the fall daytime samples at < 150 m, negative correlations ($p < 0.0005$) were seen between sewage flow rate and bacterial concentration during the nighttime at the 150 to 250 m and > 250 m downwind locations. Using the Andersen sampler, significant correlations of sewage flow rate with total aerobic bacteria-containing particle concentrations were only observed at the 150 to 250 m downwind distance. The bacteria aerosol concentration increased with the sewage flow rate ($p < 0.01$) during the spring/summer, but the inverse was observed ($p < 0.0005$) during the fall nighttime sampling periods. Aerosol concentrations of fecal streptococcus organisms were positively correlated ($p < 0.005$) with the sewage flow rate at > 250 m downwind during the spring/summer. While this positive correlation ($p < 0.005$) was also observed during the combined spring/summer and fall daytime sampling periods at this site, a negative correlation was seen with the nighttime samples taken during the same period. Significant correlations ($p < 0.01$) with sewage flow rate were not found for standard plate count organism, total coliform, or fecal coliform organisms.

Wind Direction

The influence of wind direction, and resultant sampling locations, is illustrated for total aerobic bacteria-containing particles obtained with an Andersen sampler, total coliform and fecal streptococcus aerosols in Figures 21, 22, and 23, respectively. These illustrations were made by determining the wind direction during each sampling date, shown in Appendix B, and calculating the geometric mean of the positive observations made at each downwind sampling distance and adjusting those means by multiplying the ratio of positive to total samples. That is, the mean concentrations downwind from the direction from which the wind was blowing are illustrated.

As shown in Figure 21, the greatest total aerobic-bacteria containing particle aerosol concentration increase at < 150 m downwind was observed when the wind originated from the southeast and blew diagonally over the aeration tanks. Although the concentration increased from 208 cfu/m^3 before plant operations to 930 cfu/m^3 during plant operations, this concentration was reduced to below that observed in the baseline samples at the > 250 m downwind location. While the bacterial aerosol concentration seen at < 150 m downwind during plant operations exceeded that observed before such operations began at all comparable directions, this concentration at > 250 m exceeded the baseline only when the wind blew from the north and from the southeast.

Total coliform aerosol concentrations, illustrated in Figure 22, during plant operations, exceeded those observed before such operations at all downwind sampling locations within 150 m of the center of the aeration tanks. The adjusted geometric mean concentration at this sampling distance during plant operations ranged from 1.25 cfu/m^3 at the southwest location to 12.86 cfu/m^3 at the northwest location. The highest concentrations were observed at this distance at all northerly sampling locations. Although the total coliform aerosol concentrations at the 150 to 250 m downwind sampling distance were

TABLE 22. SIGNIFICANT[a] CORRELATIONS BETWEEN SEWAGE FLOW RATE AND MICROBIAL AEROSOL CONCENTRATIONS DURING PLANT OPERATIONS

Organism	Sampling Location[b] (m)	Spring/Summer			Spring/Summer			Fall		
		Total	Day	Night	Total	Day	Night	Total	Day	Night
	Downwind									
TABCP(S)	< 150	<0.0005	--[c]	--	--	--	--	< 0.0005	< 0.0005	--
	150–250	<0.0005	--	--	--	--	--	<0.005	--	<0.0005[d](-)
	>250	--	--	--	--	--	--	--	--	<0.0005(-)
	Upwind	<0.01(-)	--	--	--	--	--	--	--	--
	Downwind									
TABCP(A)	<150	--	--	--	--	--	--	--	--	--
	150–250	--	--	--	<0.01	--	--	--	--	<0.005(-)
	>250	--	--	--	--	--	--	--	--	--
	Upwind	--	--	--	--	--	--	--	--	--
	Downwind									
FS	< 150	--	--	--	--	--	--	--	--	--
	150–250	--	--	--	--	--	--	--	--	--
	>250	--	<0.005	< 0.005(-)	< 0.005	--	--	--	--	--
	Upwind	--	--	--	--	--	--	<0.005	--	--

[a] H_0 is rejected at indicated significance level.

[b] With respect to center of aeration tanks; distances are downwind.

[c] -- indicates significant correlations not detected at $p > 0.01$.

[d] (-) indicates negative or inverse correlation.

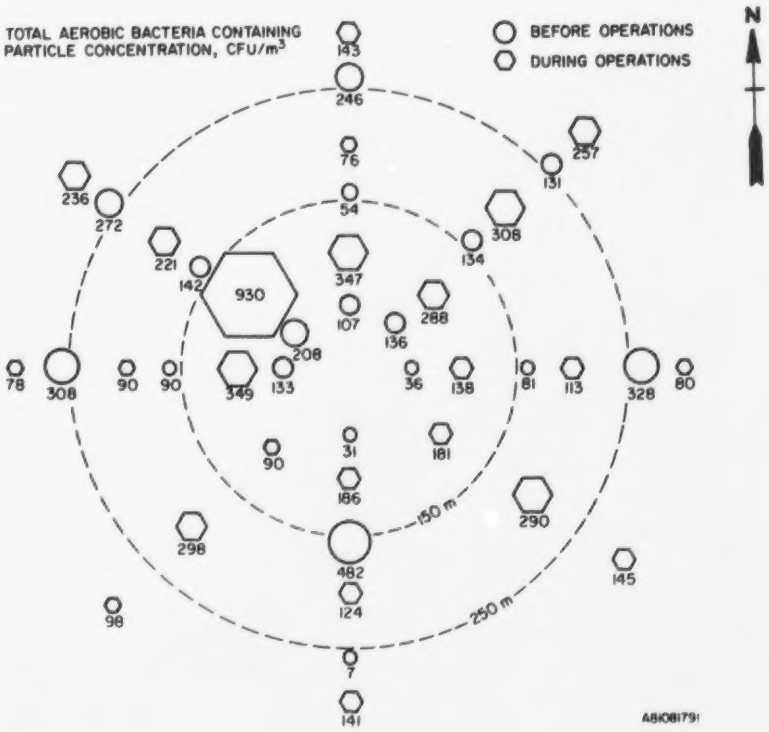
TOTAL AEROBIC BACTERIA CONTAINING PARTICLE CONCENTRATION, CFU/m³
BEFORE OPERATIONS
DURING OPERATIONS
N
143
246
76
54
347
107
31
186
482
124
7
141
257
131
308
134
288
136
36
138
81
113
328
80
181
290
145
236
272
221
142
930
208
78
308
90
90
349
133
90
298
98
150 m
250 m
A8108179

Figure 21. Directional concentration of total aerobic bacteria-containing particle aerosols determined with Andersen sampler before and during plant operations.

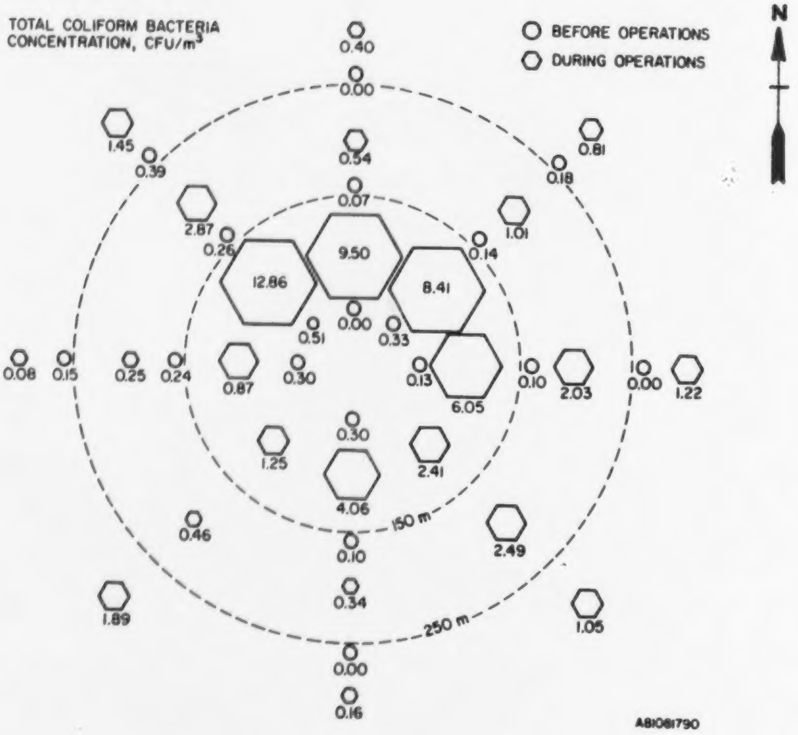
TOTAL COLIFORM BACTERIA CONCENTRATION, CFU/m³
○ BEFORE OPERATIONS
⬡ DURING OPERATIONS
N
0.40
0.00
1.45
0.39
0.54
0.07
0.81
0.18
2.87
0.26
1.01
0.14
12.86
9.50
8.41
0.00
0.51
0.33
0.08
0.15
0.25
0.24
0.87
0.30
0.13
6.05
0.10
2.03
0.00
1.22
0.30
1.25
2.41
4.06
150 m
0.46
0.10
2.49
0.34
1.89
1.05
250 m
0.00
0.16
A81081790

Figure 22. Directional concentration of total coliform bacteria-containing aerosols before and during plant operations.

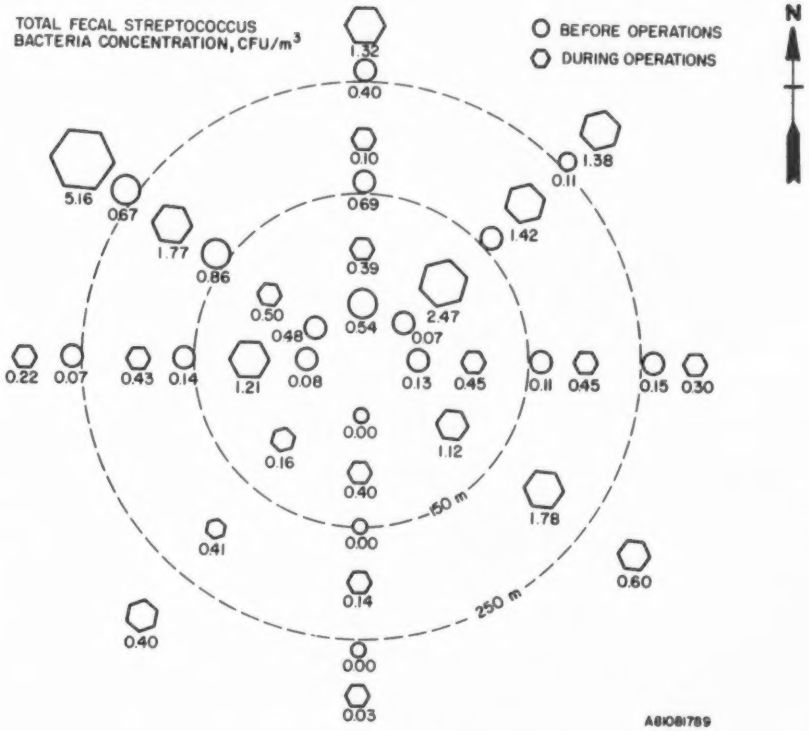
TOTAL FECAL STREPTOCOCCUS BACTERIA CONCENTRATION, CFU/m³
○ BEFORE OPERATIONS
⬡ DURING OPERATIONS
N
1.32
0.40
0.10
0.69
0.39
0.54
5.16
0.67
1.77
0.86
0.50
0.48
1.38
0.11
1.42
2.47
0.07
0.22
0.07
0.43
0.14
1.21
0.08
0.13
0.45
0.11
0.45
0.15
0.30
0.00
0.16
1.12
0.40
150 m
1.78
0.41
0.00
0.60
0.14
250 m
0.40
0.00
0.03
A81081789

Figure 23. Directional concentration of fecal streptococcus bacteria-containing aerosols before and during plant operations.

substantially lower, ranging from 0.25 cfu/m^3 on the west to 2.87 cfu/m^3 on the northwest, than those observed at the $<$ 150 m distance, these concentrations were higher than those of comparable pre-plant operation samples, which ranged from 0.07 cfu/m^3 on the north to 0.26 cfu/m^3 on the northeast. At the most distant sampling locations, $>$ 250 m downwind of the center of the aeration tanks, the total coliform aerosol concentration during plant operations ranged from 0.08 cfu/m^3 on the west to 1.89 cfu/m^3 on the southwest. These concentration ranges observed before plant operations were 0.00 cfu/m^3 on the north, east, and south to 0.39 cfu/m^3 on the northwest.

The fecal streptococcus aerosol concentration by directional location of downwind sampling sites is illustrated in Figure 23. These downwind directional fecal streptococcus concentrations were not necessarily higher at the locations more proximal ($<$ 150 m) to the center of the aeration tanks than at those sites that were more distant ($\geq$ 150 m) to this point. In fact, at the sampling sites located on the northwest side of the aeration tanks the fecal streptoccocus aerosol concentration was higher at the $>$ 250 m location (5.16 cfu/m^3) than at the $<$ 150 m (0.50 cfu/m^3) sampling location. Similarly, the aerosol concentration on the north was also higher during plant operations at the $>$ 250 m, 1.32 cfu/m^3, than at the $<$ 150 m, 0.39 cfu/m^3, sampling locations. The fecal streptococcus aerosol concentration during plant operations exceeded that observed before operation at all $<$ 150 m and 150 to 250 m locations except those located to the north of the aeration tanks. The aerosol concentration during these operations exceeded that observed in baseline samples at all sampling directions $>$ 250 m downwind of the center of the aeration tanks when comparisons were made.

Wind Velocity

The wind velocity recorded during each sampling period is presented in Appendix B. Evaluation of the correlation between wind velocity and bacteria aerosol concentration at each sampling site for total aerobic bacteria-containing particles performed with both slit and Andersen samplers, standard plate count organisms, total coliforms, fecal coliforms, and fecal streptococci was made with the Spearman rank correlation coefficient and significant correlations ($p < 0.01$) are presented in Tables 23 and 24. Examining the total aerobic bacteria-containing particles determined with slit samplers, for example, showed positive correlations ($p < 0.0005$) between aerosol concentration and wind velocity at the $<$ 150 m downwind location during plant operations during the spring/summer daytime and during the combined spring/summer and fall nighttime sampling periods ($p < 0.01$). At the 150 to 250 m location, significant positive correlations ($p < 0.005$) during plant operations were also observed between the spring/summer daytime bacteria concentrations and wind velocity. At $>$ 250 m downwind during plant operations, negative correlations ($p < 0.005$), were observed during the spring/summer nighttime, but positive correlations were seen during the fall nighttime. Significant ($p < 0.01$) negative correlations between slit sampler-determined TABCP velocity were observed at 150 to 250 m during the spring and during the combined spring and fall total and nighttime periods before plant operations were initiated. During the daytime combined spring and fall period before plant operations were initiated, the slit sampler-determined TABCP aerosol concentration at $>$ 250 m was found to increase with wind velocity

TABLE 23. SIGNIFICANT[a] CORRELATIONS BETWEEN WIND VELOCITY AND MICROBIAL AEROSOL CONCENTRATIONS BEFORE PLANT OPERATIONS

Organism	Sampling Location[b] (m)	Spring/Fall Total	Spring/Fall Day	Spring/Fall Night	Spring Total	Spring Day	Spring Night	Fall Total	Fall Day	Fall Night
	Downwind									
TABCP(S)	<150	—[c]	—	—	—	—	—	—	—	—
	150-250	< 0.0005[d](-)	—	<0.01(-)	<0.0005(-)	—	<0.005(-)	—	—	—
	>250	—	<0.01	—	—	—	—	—	—	—
	Upwind	< 0.005(-)	—	<0.005(-)	—	—	—	<0.005(-)	—	<0.0005(-)
	Downwind									
TABCP(A)	< 150	—	—	—	—	—	—	—	—	<0.005(-)
	150-250	—	—	< 0.01(-)	—	—	—	—	—	—
	>250	—	—	—	—	—	—	—	—	—
	Upwind	<0.0005(-)	—	<0.005(-)	<0.005(-)	—	<0.01(-)	—	—	<0.005(-)
	Downwind									
TC	< 150	—	—	—	—	—	—	—	—	—
	150-250	—	—	—	—	—	—	—	—	—
	>250	—	—	—	—	—	—	—	—	<0.005(-)
	Upwind	—	—	—	—	—	—	—	—	—
	Downwind									
FS	<150	—	—	—	—	—	—	—	—	—
	150-250	—	—	< 0.01	—	—	—	—	—	—
	> 250	—	—	—	—	—	—	—	—	—
	Upwind	—	—	—	—	—	—	—	—	—

[a] H_0 is rejected at indicated significance level.

[b] With respect to center of aeration tanks; distances are downwind.

[c] — indicates significant correlations not detected at $p > 0.01$.

[d] (-) indicates negative or inverse correlation.

TABLE 24. SIGNIFICANT[a] CORRELATIONS BETWEEN WIND VELOCITY AND MICROBIAL AEROSOL CONCENTRATIONS DURING PLANT OPERATIONS

Organism	Sampling Location[b] (m)	Spring/Summer + Fall			Spring/Summer			Fall		
		Total	Day	Night	Total	Day	Night	Total	Day	Night
	Downwind									
TABCP(S)	< 150	--[c]	--	<0.01	--	< 0.0005	--	--	--	--
	150–250	--	--	--	--	<0.005	--	--	--	--
	> 250	--	--	--	--	--	< 0.005(-)[d]	--	--	<0.01
	Upwind	--	--	--	--	--	--	--	--	--

---

[a] H_0 is rejected at indicated significance level.

[b] With respect to center of aeration tanks; distances are downwind.

[c] -- indicates significant correlations not detected at $p > 0.01$.

[d] (-) indicates negative or inverse correlation.

($p < 0.01$). At the upwind sampling locations, negative correlations between concentration and wind velocity were detected in the total nighttime periods during the combined spring and fall and during the fall seasons.

Total aerobic bacteria-containing particle concentrations determined with Andersen samplers were inversely correlated with wind velocity before plant operations at the < 150 m downwind site during the fall nighttime ($p < 0.005$), at the 150 to 250 m downwind site during the combined spring and fall nighttime ($p < 0.01$), and at the upwind site during both combined and separate nighttime seasons. Inverse corelations were also observed at the upwind site in the total samples during the spring and fall.

No significant ($p < 0.01$) correlations were detected between wind velocity and standard plate count organism concentration at any sampling location either before or during plant operations. Total coliform aerosol concentrations were found to be inversely related to wind velocity at 150 to 250 m downwind locations before plant operations during the daytime. No other significant correlations were detected at any site either before or during plant operations. No significant correlations could be detected between fecal coliform concentration and wind velocity at any sampling location during any sampling season. A significant direct correlation ($p < 0.01$) between fecal streptococcus aerosol concentration and wind velocity was only detected during the pre-plant operation combined spring and fall nighttime sampling period. No other significant correlations were be detected at any site.

Temperature

The temperature recorded during each sampling period is listed in Appendix B. Significant correlations between bacteria aerosol concentration and temperature are shown in Tables 25 and 26 for before and during plant operations, respectively. Total aerobic bacteria-containing particle concentrations determined with slit samplers were directly correlated ($p < 0.01$) with temperature at the < 150 m downwind locations during the fall before plant operations. During plant operations, significant positive correlations were found during the daytime during the combined as well as separate seasons. Correlations at nighttime were only observed during the spring/summer between temperature and bacteria concentration at the 150 to 250 m downwind location was also found to be significant ($p < 0.01$) during the fall daytime before plant operations, but an inverse correlation was detected at the > 250 m downwind location during the fall nighttime during plant operations. At the upwind sampling locations the bacteria concentration was only significantly directly correlated ($p < 0.005$) with temperature during the daytime during plant operations, with the most significant correlation ($p < 0.0005$) detected during the fall period.

The total aerobic bacteria-containing particle concentrations determined with Andersen samplers were directly correlated with temperature at the < 150 m downwind locations during the spring ($p < 0.005$) and during the combined spring and fall ($p <0.0005$) daytime periods before plant operations. A positive correlation between temperature and concentration at this location was also detected during the spring/summer nighttime period during plant operations. Significant positive ($p < 0.01$) correlations at the 150 to 250 m

TABLE 25. SIGNIFICANT[a] CORRELATIONS BETWEEN TEMPERATURE AND MICROBIAL AEROSOL CONCENTRATIONS BEFORE PLANT OPERATIONS

Organism	Sampling Location[b] (m)	Spring/Fall			Spring			Fall		
		Total	Day	Night	Total	Day	Night	Total	Day	Night
	Downwind									
TABCP(S)	<150	—[c]	—	—	—	—	—	—	—	—
	150–250	—	—	—	—	—	—	—	<0.01	—
	>250	—	—	—	—	—	—	—	—	—
	Upwind	—	—	—	—	—	—	—	—	—
	Downwind									
TABCP(A)	< 150	< 0.01	<0.0005	—	—	< 0.005	—	—	—	—
	150–250	—	—	<0.01	—	—	<0.01	—	—	—
	>250	<0.0005	<0.003	—	—	—	—	—	—	—
	Upwind	—	—	—	—	—	—	—	—	—
	Downwind									
SPC	< 150	<0.01	<0.01	—	—	—	—	—	—	—
	150–250	—	—	—	—	—	—	—	—	—
	>250	—	—	—	—	—	—	—	—	—
	Upwind	—	—	—	—	—	—	—	—	—
	Downwind									
PC	< 150	—	—	—	—	—	—	—	—	—
	150–250	<0.005	—	—	<0.0005	—	—	—	—	—
	>250	—	—	—	—	—	—	—	—	—
	Upwind	—	—	—	—	—	—	—	—	—

---

[a] H_0 is rejected at indicated significance level.

[b] With respect to center of aeration tanks; distances are downwind.

[c] -- indicates significant correlations not detected at $p > 0.01$.

TABLE 26. SIGNIFICANT[a] CORRELATIONS BETWEEN TEMPERATURE AND MICROBIAL AEROSOL CONCENTRATIONS DURING PLANT OPERATIONS

Organism	Sampling Location[b] (m)	Spring/Summer + Fall			Spring/Summer			Fall		
		Total	Day	Night	Total	Day	Night	Total	Day	Night
	Downwind									
TABCP(S)	<150	—[c]	<0.0005	—	—	<0.005	<0.01	< 0.0005	< 0.0005	—
	150-250	—	—	—	—	—	—	—	—	—
	>250	—	—	—	—	—	—	—	—	<0.01(-)[d]
	Upwind	—	<0.005	—	—	—	—	—	< 0.0005	—
	Downwind									
TABCP(A)	< 150	—	—	—	—	—	<0.005	—	—	—
	150-250	—	—	—	—	—	—	—	—	—
	>250	—	—	—	—	—	<0.005	—	—	—
	Upwind	—	—	< 0.01(-)	—	—	—	—	—	<0.005(-)
	Downwind									
FS	< 150	—	—	—	—	—	—	—	—	—
	150-250	—	—	—	—	—	—	—	—	—
	>250	—	—	—	—	—	—	—	—	—
	Upwind	—	< 0.005	< 0.01(-)	—	—	—	—	—	—

[a] H_0 is rejected at indicated significance level.

[b] With respect to center of aeration tanks; distances are downwind.

[c] -- indicates significant correlations not detected at $p > 0.01$.

[d] (-) indicates negative or inverse correlation.

downwind locations were observed during the spring and combined spring and fall nighttime periods before operations. At $>$ 250 m downwind from the center of the aeration tanks, the bacterial concentration was significantly directly correlated with temperature during the spring/summer nighttime ($p < 0.005$) during operations and during the spring and fall daytime ($p < 0.005$) before operations. At the upwind sampling locations, inverse correlations ($p < 0.01$) were detected between temperature and bacterial aerosol concentration during the combined spring and fall ($p < 0.01$) and during the fall ($p < 0.005$) nighttime periods.

Significant correlations between temperature and bacteria concentration with standard plate count organisms were only detected before plant operations at the $<$ 150 m downwind locations during the combined spring and fall daytime periods ($p < 0.01$). No correlations of significance between temperature and total coliform concentration were detected. Fecal coliform aerosol concentrations were significantly positively correlated only before plant operations during spring and during the combined spring and fall at the 150 to 250 m downwind locations. No other correlations of significance were detected at any other sampling location. Fecal streptococcus aerosol concentrations could not be significantly ($p < 0.01$) correlated with temperature at any downwind sampling location. A positive correlation ($p < 0.005$) between fecal streptococcus concentration and temperature was, however, detected during plant operations at the upwind sampling locations during the spring/summer and fall combined daytime period and a negative correlation ($p < 0.01$) was found observed at nighttime during this same study period.

Relative Humidity

The percent relative humidity (RH) observed during each sampling trial is listed in Appendix B. Significant correlations between bacteria concentration and RH are shown in Tables 27 and 28 for before and during plant operations, respectively. Significant positive correlations between total aerobic bacteria-containing particle concentrations determined with slit samplers and RH were only observed during the daytime while such inverse correlations were only found at nighttime. At $<$ 150 m downwind locations, for example, during the fall of plant operation these aerosol concentrations were directly related to RH ($p < 0.0005$) during the daytime and inversely related to RH ($p < 0.0005$) during the nighttime. Likewise, at this same location during the combined spring/summer and fall during plant operation significant direct correlations were found during the daytime ($p < 0.005$) and inverse correlations were detected at nighttime ($p < 0.0005$). At the 150 to 250 m downwind locations, an inverse relationship ($p < 0.01$) between bacterial concentration and RH was detected during the nighttime of fall and of the combined spring/summer and fall seasons during plant operation. Inverse correlations were also observed < 0.01) and at the upwind ($p < 0.005$) sampling locations. At the upwind locations these significant inverse correlations ($p < 0.005$) were also detected in the total samples as well as at nighttime during the combined total study period. No significant correlations between RH and slit sampler determined bacteria aerosol concentration was detected before the plant began operating.

TABLE 27. SIGNIFICANT[a] CORRELATIONS BETWEEN RELATIVE HUMIDITY AND MICROBIAL AEROSOL CONCENTRATIONS BEFORE PLANT OPERATIONS

Organism	Sampling Location[b] (m)	Spring/Fall			Spring			Fall		
		Total	Day	Night	Total	Day	Night	Total	Day	Night
	Downwind									
TABCP (A)	<150	<0.005	—[c]	—	—	—	—	—	—	—
	150–250	—	—	<0.005(-)[d]	—	—	<0.01(-)	—	—	—
	>250	—	—	—	—	—	—	—	—	—
	Upwind	—	—	—	<0.0005(-)	—	—	—	—	—
	Downwind									
FC	<150	—	—	—	—	—	—	—	—	—
	150–250	<0.005(-)	—	—	—	—	—	—	—	—
	>250	—	—	—	—	—	—	—	—	—
	Upwind	—	—	—	—	—	—	—	—	—
	Downwind									
FS	<150	—	—	—	—	—	—	—	—	—
	150–250	<0.005	—	—	<0.01	—	—	—	—	—
	>250	—	—	—	—	—	—	—	—	—
	Upwind	—	—	—	—	—	—	—	—	—

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[a] H_0 is rejected at indicated significance level.

[b] With respect to center of aeration tanks; distances are downwind.

[c] — indicates significant correlations not detected at $p > 0.01$.

[d] (-) indicates negative or inverse correlation.

TABLE 28. SIGNIFICANT[a] CORRELATIONS BETWEEN RELATIVE HUMIDITY AND MICROBIAL AEROSOL CONCENTRATIONS DURING PLANT OPERATIONS

Organism	Sampling Location[b] (m)	Spring/Summer + Fall Total	Spring/Summer + Fall Day	Spring/Summer + Fall Night	Spring/Summer Total	Spring/Summer Day	Spring/Summer Night	Fall Total	Fall Day	Fall Night
	Downwind									
TABCP(S)	<150	<0.01	<0.005	<0.0005(-)[c]	--[d]	--	--	--	<0.0005	<0.0005(-)
	150-250	--	--	<0.01(-)	--	--	--	--	--	<0.01(-)
	>250	--	--	--	--	--	--	--	--	<0.01(-)
	Upwind	<0.005	--	<0.0005	--	--	--	--	--	<0.005(-)
	Downwind									
TABCP(A)	<150	--	--	<0.005(-)	--	--	--	--	--	<0.01(-)
	150-250	--	--	--	<0.01	--	--	<0.005(-)	<0.005(-)	--
	>250	--	--	<0.0005(-)	--	--	<0.005(-)	--	--	<0.05(-)
	Upwind	--	--	--	<0.01(-)	--	--	--	--	--
	Downwind	--	--	--	--	--	--	--	--	--
TC	<150	--	--	--	--	--	--	--	--	--
	150-250	--	--	--	<0.005	--	--	--	--	--
	>250	--	--	--	--	--	--	--	--	--
	Upwind	--	--	--	--	--	--	--	--	--

---

[a] H_0 is rejected at indicated significance level.

[b] With respect to center of aeration tanks; distances are downwind.

[c] (-) indicates negative or inverse correlation.

[d] -- indicates significant correlations not detected at $p > 0.01$.

Total aerobic bacteria-containing particle aerosol concentrations determined with Andersen samplers were inversely correlated to RH at the < 150 m downwind locations during the nighttime combined spring/summer and fall ($p < 0.01$) during plant operations and during the combined spring and fall ($p < 0.005$) before operations. These inverse correlations were also observed at the 150 to 250 m downwind locations before plant operations during the combined nighttime spring and fall ($p < 0.005$), and during the spring nighttime ($p < 0.01$). During plant operations, inverse correlations were seen during the total and daytime fall samples ($p < 0.005$). A direct correlation ($p < 0.01$) between bacterial aerosol concentration and RH was detected during the spring/summer during plant operations. At the > 250 m downwind locations, significant negative correlations were detected during the spring/summer and during the fall spring/summer nighttime ($p < 0.0005$) during plant operations. At the upwind sampling locations, significant inverse correlations ($p < 0.0005$) between bacteria concentration and RH were observed in the total samples taken during the spring or spring/summer seasons both before and during plant operations.

No significant correlations between standard plate count organism concentration and RH could be detected at any sampling location during any sampling season. A significant positive correlation between total coliform aerosol concentration and RH ($p < 0.005$) was detected at the 150 to 250 m downwind location during the combined day- and nighttime spring/summer during plant operations. With fecal coliform aerosols, a significant ($p < 0.005$) negative correlation between concentration and RH was only detected during the combined spring and fall seasons before plant operations. Fecal streptococcus aerosol concentrations were only significantly positively correlated with RH at the 150 to 250 m downwind location before plant operations during the spring ($p < 0.01$) and the combined spring and fall ($p < 0.005$) sampling periods.

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APPENDIX A. SAMPLE SUMMARY

Trial No.	Date	Scheme	Day- or Nighttime	Trial No.	Date	Scheme	Day- or Nighttime
	(Fall 1978)				(Spring/Summer 1980)		
1	no sample						
2	10/3	A	D	43	5/19	A,Bc	D
3	10/6	A,Bc	N	44	6/18	C	N
4	10/11	A,Bs	N	45	6/26	A,Bs	D
5	10/14	C	D	46	7/7	A,Bs	N
6	10/18	C	N	47	7/11	A,Bc	N
7	10/23	A,Bs	D	48	7/15	C	N
	(Spring 1979)			49	7/23	A,Bs	D
8	no sample			50	7/28	A,Bc	D
9	4/8	A,Bs	D	51	8/1	C	D
10	4/12	C	N	52	8/5	A,Bs	D
11	4/16	A,Bc	D	53	8/12	A,Bc	N
12	4/20	A,Bs	N	54	8/15	A,Bs	N
13	4/24	C	N	55	8/18	C	N
14	4/28	A,Bc	N	56	8/21	A,Bc	N
15	5/2	A,Bs	N		(Fall 1980)		
16	5/7	C	D	57	8/26	C	D
17	5/10	A,Bc	D	58	9/3	A,Bc	D
18	5/15	A,Bs	N	59	9/5	A,Bs	D
19	5/18	C	N	60	9/8	C	N
20	5/22	A,Bc	D	61	9/11	A,Bs	N
21	5/30	C	D	62	9/19	C	N
22	6/3	C	N	63	9/23	C	D
23	6/6	A,Bc	N	64	9/24	A,Bs	N
24	6/11	A,Bc	N	65	9/29	A,Bc	D
25	6/14	A,Bs	D	66	10/2	C	D
	(Fall 1979)			67	10/7	A,Bs	N
26	8/15	C	D	68	10/10	A,Bc	N
27	8/23	A,Bs	N	69	10/17	C	D
28	8/27	A,Bs	D	70	10/20	A,Bs	N
29	9/4	A,Bc	N	71	10/24	A,Bc	N
30	9/8	C	N	72	10/28	C	D
31	9/12	A,Bs	N	73	10/31	A,Bs	D
32	9/20	A,Bc	D	74	11/3	C	D
33	9/24	A,Bc	N	75	11/5	A,Bc	D
34	9/29	C	N	76	11/10	A,Bs	D
35	10/2	C	D	77	11/12	A,Bc	D
36	10/8	A,Bs	D				
37	10/11	A,Bc	D				
38	10/18	C	N				
39	10/22	C	D				
40	10/30	A,Bs	D				
41	10/30	A,Bs	N				
42	11/7	A,Bc	D				

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APPENDIX B. ENVIRONMENTAL AND METEOROLOGICAL CONDITIONS

TABLE B-1. SEWAGE AND AIR FLOW DATA

Trial No.	Sewage Flow, MGD	Air Flow, ft^3/gal
43	18.50	0.56
44	19.90	0.63
45	20.90	0.60
46	21.60	0.60
47	20.40	0.69
48	21.30	0.63
49	22.50	0.82
50	19.60	0.88
51	17.70	0.97
52	37.50	0.49
53	24.90	0.64
54	27.30	0.57
55	32.00	0.55
56	37.40	0.50
57	21.70	0.76
58	27.70	0.55
59	22.30	0.78
60	28.30	0.65
61	34.30	0.53
62	36.70	0.47
63	48.40	0.37
64	33.10	0.59
65	27.90	0.73
66	29.18	0.65
67	23.43	0.54
68	22.90	0.75
69	42.69	0.29
70	29.60	0.48
71	37.80	0.44
72	23.05	0.68
73	19.51	0.74
74	22.69	0.57
75	19.89	0.66
76	14.83	0.89
77	19.18	0.59

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TABLE B-2. METEOROLOGICAL CONDITIONS DURING SAMPLING TRIALS

TRIAL NO.	WIND DIRECTION (1-8)	WIND VELOCITY (m/s)	TEMPERATURE (°C)	RELATIVE HUMIDITY (%)
1	8	4	15	87
2	5	4	17	84
3	6	6	11	83
4	4	6	16	60
5	7	3	3	85
6	4	4	9	63
7	0	7	11	57
9	0	4	5	83
10	4	11	23	54
11	6	2	13	41
12	5	7	17	50
13	4	6	16	83
14	2	2	4	83
15	5	9	26	39
16	5	10	23	57
17	5	6	28	55
18	4	3	13	54
19	4	8	24	34
20	3	4	19	36
21	2	7	23	50
22	3	3	19	40
23	3	3	18	44
24	0	0	20	42
25	5	7	28	51
26	0	7	20	46
27	6	5	24	70
28	5	4	23	74
29	3	3	17	89
30	3	3	13	70
31	4	3	17	90
32	5	7	24	40
33	5	2	14	83
34	4	2	19	71
35	0	6	17	74
36	2	3	18	48
37	5	7	10	71
38	4	7	19	70
39	5	9	24	60
40	6	5	7	56

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TABLE B-2, CONTINUED

TRIAL NO.	WIND DIRECTION (1-8)	WIND VELOCITY (m/s)	TEMPERATURE (°C)	RELATIVE HUMIDITY (%)
41	3	5	13	59
42	5	6	3	57
43	0	2	23	39
44	0	0	14	69
45	6	4	33	78
46	5	9	32	61
47	3	2	27	64
48	7	3	33	50
49	1	3	27	60
50	8	4	27	42
51	6	5	30	44
52	5	4	24	80
53	2	3	21	68
54	1	4	18	79
55	4	3	23	78
56	7	2	23	65
57	5	4	29	50
58	4	5	29	76
59	4	4	24	52
60	4	5	25	83
61	2	4	21	55
62	4	7	22	61
63	8	2	18	60
64	6	5	16	68
65	4	3	18	79
66	5	5	20	90
67	5	5	17	45
68	5	5	13	38
69	5	8	19	90
70	5	4	11	68
71	6	5	5	84
72	8	5	4	45
73	6	7	14	40
74	5	9	17	60
75	8	5	8	45
76	8	4	4	60
77	4	5	5	76

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APPENDIX C. SUMMARY OF BACTERIAL AEROSOL CONCENTRATIONS

TABLE C-1. TABCP CONCENTRATION USING SLIT SAMPLER AT SITES LOCATED <150 m DOWNWIND FROM THE CENTER OF THE AERATION TANKS

Day- and Nighttime			Daytime		Nighttime	
Trial No.	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3
3	7	9.8			7	9.8
4	3	122.2			3	122.2
6	6	14.4			6	14.4
7	3	8.5	3	8.5		
9	1	25.6	1	25.6		
10	5	30.1	5	30.1		
11	1	42.3	1	42.3		
12	1	14.3			1	14.3
14	1	76.2			1	76.2
15	1	36.9	1	36.9		
16	6	62.1	6	62.1		
17	4	29.8	4	29.8		
18	2	157.5			2	157.5
19	4	173.6			4	173.6
20	2	13.1	2	13.1		
22	6	167.0			6	167.0
23	2	63.0			2	63.0
24	2	248.8			2	248.8
25	5	87.5	5	87.5		
26	6	52.4	6	52.4		
27	3	29.3	1	50.0	2	22.5
29	2	44.5	1	87.5	1	22.6
30	5	155.2	1	86.3	4	179.8
31	3	221.7	1	306.0	2	188.7
33	1	70.8			1	70.8
34	6	89.3			6	89.3
35	6	2.7	6	2.7		
36	2	118.5	2	118.5		
37	3	89.8	3	89.8		
38	7	47.0			7	47.0
39	3	98.7	3	98.7		
40	3	21.0	3	21.0		
41	2	55.0			2	55.0
42	3	28.5	3	28.5		
43	3	20.3	3	20.3		
44	6	64.1	1	126.3	5	56.0
45	3	43.7	3	43.7		
46	3	103.2	1	101.3	2	104.2
47	3	349.0	1	325.0	2	361.7
48	12	257.2	1	148.0	11	270.4
49	5	36.3	5	36.3		

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TABLE C-1, CONT. TABCP CONCENTRATION USING SLIT SAMPLER AT SITES LOCATED < 150 m DOWNWIND FROM THE CENTER OF THE AERATION TANKS

Day- and Nighttime			Daytime		Nighttime	
Trial No.	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3
50	5	36.3	5	36.3		
51	17	79.9	17	79.9		
52	5	23.6	5	23.6		
53	1	153.1			1	153.1
54	1	150.0			1	150.0
55	9	174.7	1	195.2	8	172.3
56	3	99.6			3	99.6
57	12	45.7	12	45.7		
58	5	67.0	5	67.0		
59	5	136.7	5	136.7		
60	9	190.1	2	141.3	7	207.0
61	5	278.8	1	204.8	4	301.1
62	12	390.5	1	606.0	11	375.2
63	13	61.0	13	61.0		
64	5	40.2	1	64.7	4	35.7
65	5	34.9	5	34.9		
66	26	87.8	26	87.8		
67	4	682.0	1	753.6	3	659.7
68	5	575.1	1	660.1	4	555.7
69	13	92.6	13	92.6		
70	5	610.9	1	578.6	4	619.3
71	5	176.2			5	176.2
72	13	40.4	13	40.4		
73	5	29.5	5	29.5		
74	12	21.1	12	21.1		
75	5	59.6	5	59.6		
76	4	13.9	4	13.9		
77	5	26.9	5	26.9		

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TABLE C-3. TABCP CONCENTRATION USING SLIT SAMPLER AT SITES LOCATED >250 m DOWNWIND FROM THE CENTER OF THE AERATION TANKS

Day- and Nighttime			Daytime		Nighttime	
Trial No.	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3
3	5	11.7			5	11.7
7	1	73.8	1	73.8		
9	2	50.2	2	50.2		
11	2	40.5	2	40.5		
12	2	52.6			2	52.6
20	1	72.2	1	72.2		
27	2	46.6			2	46.6
29	1	142.3			1	142.3
31	2	477.5			2	477.5
32	3	283.3	3	283.3		
33	1	44.5			1	44.5
36	3	33.8	3	33.8		
41	3	130.8	1	79.2	2	168.1
42	3	46.7	3	46.7		
43	3	18.0	3	18.0		
45	3	33.2	3	33.2		
46	3	29.8	1	60.9	2	20.8
47	3	147.1	1	156.0	2	142.8
49	3	62.1	3	62.1		
52	3	53.9	3	53.9		
53	3	132.3			3	132.3
54	2	43.1			2	43.1
56	3	109.2	1	117.3	2	105.4
58	3	42.9	3	42.9		
59	3	79.9	3	79.9		
61	3	60.8	1	69.0	2	57.0
64	3	96.4	1	60.1	2	122.1
65	3	47.5	3	47.5		
67	3	171.9	1	140.5	2	190.2
68	3	382.0	1	576.8	2	310.9
73	3	71.5	3	71.5		
75	3	5.5	3	5.5		
76	3	121.6	3	121.6		

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TABLE C-2. TABCP CONCENTRATION USING SLIT SAMPLER AT SITES LOCATED 150 TO 250 m DOWNWIND FROM THE CENTER OF THE AERATION TANKS

Day- and Nighttime			Daytime		Nighttime	
Trial No.	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3
2	1	100.0	1	100.0		
3	6	45.6			6	45.6
4	2	15.9			2	15.9
5	4	25.6	2	43.5	2	15.1
7	4	7.6	4	7.6		
11	1	29.0	1	29.0		
12	1	10.7			1	10.7
13	1	20.7			1	20.7
14	5	127.7			5	127.7
15	2	24.5	2	24.5		
17	1	436.3	1	436.3		
20	1	30.4	1	30.4		
21	6	10.9	6	10.9		
23	4	164.5			4	164.5
24	3	353.3			3	353.3
27	3	46.4			3	46.4
28	6	39.0	6	39.0		
29	3	93.2			3	93.2
31	2	163.6			2	163.6
32	2	168.2	2	168.2		
33	2	51.2	1	59.5	1	44.0
36	2	10.3	2	10.3		
37	4	43.5	4	43.5		
40	4	24.2	4	24.2		
41	3	177.0	1	161.9	2	185.1
42	3	20.3	3	20.3		
43	3	7.7	3	7.7		
45	3	34.2	3	34.2		
46	3	78.6	1	80.3	2	77.8
47	3	81.0	1	66.5	2	89.4
49	1	34.5	1	34.5		
50	6	51.9	6	51.9		
52	3	27.7	3	27.7		
53	2	108.3			2	108.3
54	3	43.2	1	54.2	2	38.6
56	3	192.4			3	192.4
58	3	15.5	3	15.5		
59	2	135.2	2	135.2		
61	2	46.9			2	46.9
64	3	83.3	1	62.5	2	96.1
65	3	47.2	3	47.2		
67	3	369.6	1	369.3	2	369.7
68	2	293.0			2	293.0
70	5	251.4	1	326.8	4	235.4
71	5	53.0	1	36.3	4	58.2
73	3	47.9	3	47.9		
75	2	16.9	2	16.9		
76	3	13.7	3	13.7		
77	5	21.9	5	21.9		

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TABLE C-4. TABCP CONCENTRATION USING SLIT SAMPLER AT SITES LOCATED UPWIND FROM THE CENTER OF THE AERATION TANKS

Day- and Nighttime			Daytime		Nighttime	
Trial No.	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3
1	2	21.6	2	21.6		
2	2	44.5	2	44.5		
3	6	17.6			6	17.6
4	4	92.3			4	92.3
5	5	15.8	4	15.0	1	19.6
6	7	40.7			7	40.7
7	3	140.1	3	140.1		
9	1	11.7	1	11.7		
10	4	21.1	4	21.1		
11	3	23.0	3	23.0		
12	2	49.2			2	49.2
14	1	139.8			1	139.8
15	2	15.9	2	15.9		
16	7	107.7	7	107.7		
17	3	22.8	3	22.8		
18	2	20.4			2	20.4
19	6	107.0			6	107.0
20	3	22.8	3	22.8		
21	6	10.1	6	10.1		
22	6	219.7			6	219.7
23	1	79.2			1	79.2
24	2	179.1			2	179.1
25	2	18.6	2	18.6		
26	6	23.2	6	23.2		
27	2	60.9			2	60.9
28	2	9.8	2	9.8		
29	2	157.7			2	157.7
30	7	183.7	1	123.8	6	196.2
32	2	166.6	2	166.6		
33	2	105.3			2	105.3
34	6	130.2			6	130.2
35	5	11.4	5	11.4		
36	2	174.3	2	174.3		
37	2	27.1	2	27.1		
38	6	13.3			6	13.3
39	3	124.8	3	124.8		
40	3	9.0	3	9.0		
41	2	21.0			2	21.0
42	2	118.7	2	118.7		
43	3	24.1	3	24.1		
44	4	42.2			4	42.2
45	2	14.4	2	14.4		
46	2	52.1	1	38.2	1	71.1
47	3	110.5	1	92.2	2	121.0
48	7	46.2	1	165.7	6	37.3
49	3	53.5	3	53.5		
50	3	175.2	3	175.2		
51	13	53.6	13	53.6		
52	3	16.7	3	16.7		
53	2	66.1			2	66.1

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TABLE C-4, Cont. TABCP CONCENTRATION USING SLIT SAMPLER AT SITES LOCATED UPWIND FROM THE CENTER OF THE AERATION TANKS

Day- and Nighttime			Daytime		Nighttime	
Trial No.	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3
54	2	36.9			2	36.9
55	6	59.7	1	94.6	5	54.5
56	2	57.6			2	57.6
57	10	44.7	10	44.7		
58	3	32.3	3	32.3		
59	3	63.4	3	63.4		
60	6	17.3	1	25.3	5	16.1
61	3	21.6	1	11.3	2	29.9
62	5	243.3			5	243.3
63	6	33.6	6	33.6		
64	3	148.6	1	103.1	2	178.3
65	3	39.6	3	39.6		
66	12	35.1	12	35.1		
67	3	206.4	1	212.5	2	203.4
68	3	345.8	1	406.0	2	319.1
69	6	23.1	6	23.1		
70	3	304.1	1	291.1	2	310.8
71	3	31.2	1	24.4	2	35.3
72	7	4.6	7	4.6		
73	2	67.3	2	67.3		
74	6	40.6	6	40.6		
75	3	25.3	3	25.3		
76	3	26.4	3	26.4		
77	3	12.7	3	12.7		

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TABLE C-5. TABCP CONCENTRATION USING ANDERSEN SAMPLER AT SITES LOCATED <150 m DOWNWIND FROM THE CENTER OF THE AERATION TANKS

Day- and Nighttime			Daytime		Nighttime	
Trial No.	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3
3	2	65.3			2	65.3
4	1	54.8			1	54.8
6	3	119.1			3	119.1
7	1	5.9	1	5.9		
10	2	138.5	2	138.5		
12	2	96.7			2	96.7
15	2	178.7	2	178.7		
16	4	39.9	4	39.9		
17	3	204.7	3	204.7		
19	5	206.1			5	206.1
20	1	105.9	1	105.9		
22	6	342.1			6	342.1
23	2	60.5			2	60.5
25	6	284.9	6	284.9		
26	6	39.0	6	39.0		
27	1	35.7			1	35.7
29	1	1090.5			1	1090.5
30	3	86.6			3	86.6
31	2	39.8			2	39.8
32	2	247.6	2	247.6		
33	1	89.3			1	89.3
34	5	197.1			5	197.1
35	5	23.9	5	23.9		
36	2	133.3	2	133.3		
37	2	145.5	2	145.5		
38	6	47.4			6	47.4
39	3	140.1	3	140.1		
41	2	367.6			2	367.6
42	2	63.1	2	63.1		
43	2	41.4	2	41.4		
44	4	66.4			4	66.4
45	1	89.3	1	89.3		
46	2	179.7			2	179.7
47	2	930.5			2	930.5
48	6	408.7			6	408.7
49	2	113.8	2	113.8		
50	2	401.5	2	401.5		
51	4	153.4	4	153.4		
52	2	134.5	2	134.5		
53	2	268.9			2	268.9
54	2	70.1			2	70.1
55	3	238.9	1	192.9	2	265.9
56	2	180.7			2	180.7
57	6	284.5	6	284.5		
58	2	194.3	2	194.3		
59	2	911.4	2	911.4		
60	6	360.6	1	407.1	5	352.0
61	2	453.7			2	453.7
62	6	459.1			6	459.1
63	6	200.6	6	200.6		

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TABLE C-5, CONT. TABCP CONCENTRATION USING ANDERSEN SAMPLER AT SITES LOCATED <150 m DOWNWIND FROM THE CENTER OF THE AERATION TANKS

Day- and Nighttime			Daytime		Nighttime	
Trial No.	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3
64	2	124.4			2	124.4
65	2	251.1	2	251.1		
66	6	356.8	6	356.8		
67	2	513.0	1	583.3	1	451.2
68	1	678.6			1	678.6
69	6	288.7	6	288.7		
70	2	666.5			2	666.5
71	2	214.9			2	214.9
72	6	358.2	6	358.2		
73	2	100.9	2	100.9		
74	6	190.0	6	190.0		
75	2	438.1	2	438.1		
76	2	144.1	2	144.1		
77	2	218.3	2	218.3		

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TABLE C-6. TABCP CONCENTRATION USING ANDERSEN SAMPLER AT SITES LOCATED 150 TO 250 m DOWNWIND FROM THE CENTER OF THE AERATION TANKS

Day- and Nighttime			Daytime		Nighttime	
Trial No.	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3
1	1	84.5	1	84.5		
2	1	32.1	1	32.1		
3	4	54.4			4	54.4
4	2	80.4			2	80.4
5	3	161.8	3	161.8		
7	2	14.6	2	14.6		
11	1	67.7	1	67.7		
12	1	101.2			1	101.2
13	2	35.4			2	35.4
17	2	214.8	2	214.8		
18	1	52.4			1	52.4
21	6	80.0	6	80.0		
23	2	219.7			2	219.7
24	3	481.6			3	481.6
27	2	108.4			2	108.4
28	2	82.9	2	82.9		
29	2	123.6			2	123.6
31	2	82.0			2	82.0
32	2	130.0	2	130.0		
36	2	130.7	2	130.7		
37	4	232.9	4	232.9		
40	3	70.9	3	70.9		
41	2	105.2			2	105.2
42	2	54.1	2	54.1		
43	2	38.7	2	38.7		
45	1	64.3	1	64.3		
46	2	93.9			2	93.9
47	2	221.2			2	221.2
50	4	149.1	4	149.1		
52	2	243.4	2	243.4		
53	2	244.0			2	244.0
54	2	297.8			2	297.8
56	1	290.5			1	290.5
58	2	36.9	2	36.9		
59	2	341.3	2	341.3		
61	2	33.1			2	33.1
64	2	78.1			2	78.1
65	2	63.6	2	63.6		
67	2	339.7	1	348.8	1	330.9
68	2	454.5			2	454.5
70	4	493.0			4	493.0
71	4	113.9			4	113.9
73	2	213.8	2	213.8		
75	2	253.6	2	253.6		
76	1	141.7	1	141.7		
77	4	56.6	4	56.6		

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TABLE C-7. TABCP CONCENTRATION USING ANDERSEN SAMPLER AT SITES LOCATED >250 m DOWNWIND FROM THE CENTER OF THE AERATION TANKS

Day- and Nighttime			Daytime		Nighttime	
Trial No.	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3
3	3	54.6			3	54.6
7	2	37.3	2	37.3		
9	1	7.2	1	7.2		
11	2	263.7	2	263.7		
18	1	159.5			1	159.5
20	1	273.8	1	273.8		
27	2	407.2			2	407.2
29	1	814.3			1	814.3
31	2	306.2			2	306.2
32	2	352.0	2	352.0		
33	2	157.0			2	157.0
36	2	307.7	2	307.7		
41	2	156.7			2	156.7
42	2	40.3	2	40.3		
43	2	35.1	2	35.1		
45	2	37.9	2	37.9		
46	2	123.2			2	123.2
47	2	236.3			2	236.3
49	2	272.8	2	272.8		
52	2	158.9	2	158.9		
53	2	59.5			2	59.5
54	2	35.5			2	35.5
56	2	145.2			2	145.2
58	2	183.1	2	183.1		
59	2	180.3	2	180.3		
61	2	103.2			2	103.2
64	2	93.3			2	93.3
65	2	88.7	2	88.7		
67	2	426.1	1	490.5	1	370.2
68	2	520.1			2	520.1
73	2	144.5	2	144.5		
75	2	116.7	2	116.7		
76	2	682.0	2	682.0		

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TABLE C-8. TABCP CONCENTRATION USING ANDERSEN SAMPLER AT SITES LOCATED UPWIND FROM THE CENTER OF THE AERATION TANKS

Day- and Nighttime			Daytime		Nighttime	
Trial No.	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3
2	1	56.0	1	56.0		
3	1	39.3			1	39.3
4	2	36.5			2	36.5
5	3	135.2	2	153.5	1	104.8
6	4	33.0			4	33.0
7	1	44.0	1	44.0		
9	2	51.2	2	51.2		
10	4	19.3	4	19.3		
11	1	110.6	1	110.6		
12	2	49.1			2	49.1
13	2	29.7			2	29.7
14	2	230.3			2	230.3
16	4	118.3	4	118.3		
17	2	69.7	2	69.7		
18	1	50.0			1	50.0
19	5	162.4			5	162.4
20	2	168.2	2	168.2		
21	6	57.6	6	57.6		
22	5	303.1			5	303.1
23	2	181.8			2	181.8
24	1	511.9			1	511.9
25	2	93.0	2	93.0		
26	5	147.9	5	147.9		
27	1	85.7			1	85.7
28	2	89.3	2	89.3		
29	1	123.8			1	123.8
30	4	169.1			4	169.1
31	2	108.9			2	108.9
32	2	339.3	2	339.3		
33	2	119.0			2	119.0
34	2	213.8			2	213.8
35	5	136.7	5	136.7		
36	1	271.4	1	271.4		
37	2	92.8	2	92.8		
38	6	24.8			6	24.8
39	3	92.8	3	92.8		
40	1	275.0	1	275.0		
41	2	53.2			2	53.2
42	2	129.1	2	129.1		
43	2	34.5	2	34.5		
44	6	42.9			6	42.9
45	2	12.8	2	12.8		
46	2	24.4			2	24.4
47	2	164.8			2	164.8
48	6	133.4			6	133.4
49	2	125.9	2	125.9		
50	2	485.7	2	485.7		
51	6	132.6	6	132.6		
52	2	55.6	2	55.6		
53	2	167.3			2	167.3

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TABLE C-8, CONT. TABCP CONCENTRATION USING ANDERSEN SAMPLET AT SITES LOCATED UPWIND FROM THE CENTER OF THE AERATION TANKS

Day- and Nighttime			Daytime		Nighttime	
Trial No.	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3	No. of Samples	cfu/m^3
54	2	113.0			2	113.0
55	6	46.4	1	60.7	5	43.9
56	2	110.5			2	110.5
57	6	71.7	6	71.7		
58	2	64.9	2	64.9		
59	2	76.5	2	76.5		
60	6	19.6	1	32.1	5	17.7
61	2	12.1			2	12.1
62	4	35.1	1	58.3	3	29.6
63	6	86.6	6	86.6		
64	2	102.7	1	126.7	1	83.3
65	2	71.1	2	71.1		
66	5	128.3	5	128.3		
67	2	259.5	1	253.6	1	265.5
68	2	559.0			2	559.0
69	6	114.2	6	114.2		
70	2	324.1			2	324.1
71	2	38.1			2	38.1
72	6	20.9	6	20.9		
73	2	239.9	2	239.9		
74	6	115.7	6	115.7		
75	2	117.2	2	117.2		
76	2	47.1	2	47.1		
77	2	64.2	2	64.2		

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TABLE C-9. STANDARD PLATE COUNT ORGANISM AEROSOL CONCENTRATION AT SITES LOCATED <150 m DOWNWIND FROM THE CENTER OF THE AERATION TANKS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
4		27.46
7	15661.20	
9	0.00	
11	194.30	
12		11.30
14		8.80
15	234.40	
17	64250.00	
17	81750.00	
18		80.10
20	17.50	
23		30.90
24		58.75
25	26.30	
25	1370.19	
27		80.65
29		38.10
31		46.08
32	106.91	
33		42.35
36	21.66	
37	224.04	
40	21.84	
41		86.85
42	24.59	
43	30352.94	
45	64.87	
46		61.79
47		247.16
49	77.90	
50	35.31	
52	334.32	
53		101.45
54		137.68
56		38.52
58	70.63	
59	876.40	
61		1584.12
64		224.64
65	387.68	
67		8828.25
68		12113.06
70		1087.73
71		130.83
73	141.30	
75	108.70	
76	97.83	
77	683.53	

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TABLE C-10. STANDARD PLATE COUNT ORGANISM AEROSOL CONCENTRATION AT SITES LOCATED 150 TO 250 m DOWNWIND FROM THE CENTER OF THE AERATION TANKS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
2	12.00	
3		208.00
4		19200.00
7	30.60	
11	13125.00	
12		20.00
14		62.70
14		185.00
15	305.00	
15	152.50	
17	75454.60	
18		86.30
20	35.00	
23		32.50
23		59.80
24		135.00
24		234.20
27		94.87
28	7.49	
28	17.23	
28	7.94	
29		43.63
31		55.56
32	90.28	
33		73.73
36	64.10	
37	130.49	
37	92.42	
40	26.88	
40	9.59	
41		66.09
42	54.55	
43	36.11	
45	55.64	
46		48.91
47		561.80
49	117.29	
50	63.41	
50	52.97	
52	126.81	
53		646.03
54		226.32
56		156.82
58	45.29	
59	153.99	
61		32.10
64		130.02
65	40.38	
67		4511.28
68		3964.46
70		679.43
70		487.32
71		210.27
71		154.90
73	109.77	
75	91.73	
76	669.78	
77	59.39	
77	103.26	

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TABLE C-11. STANDARD PLATE COUNT ORGANISM AEROSOL CONCENTRATION AT SITES LOCATED >250 m DOWNWIND FROM THE CENTER OF THE AERATION TANKS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
3		88.00
7	800.00	
9	0.00	
11	2000.00	
12		66.70
18		61.90
20	45.30	
27		53.57
29		66.67
31		55.29
32	76.19	
33		64.31
36	55.14	
41		61.10
42	32.05	
43	13.64	
45	114.75	
46		125.71
47		117.75
49	46.66	
52	130.02	
53		46.55
54		113.51
56		81.20
58	133.10	
59	753.25	
61		32.61
64		546.82
65	52.97	
68		1010.25
73	75.44	
75	32.10	
76	4090.23	

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TABLE C-12. STANDARD PLATE COUNT ORGANISM AEROSOL CONCENTRATION AT SITES LOCATED UPWIND FROM THE CENTER OF THE AERATION TANKS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
2	80.00	
4		663.00
7	288.00	
9	2.30	
11	1666.70	
12		21.30
14		110.00
15	37.50	
17	70040.30	
18		125.00
20	8.50	
23		50.00
24		160.00
25	85.00	
27		37.18
28	37.11	
29		39.06
31		38.10
32	78.13	
33		6.35
36	19.35	
37	67.86	
40	56.06	
41		60.71
42	30.95	
43	46.15	
45	31.58	
46		44.94
47		162.41
49	36.92	
50	2496.24	
52	76.72	
53		114.29
54		526.24
56		75.37
58	115.75	
59	601.06	
61		36.09
65	697.74	
67		7617.77
68		912.47
70		366.26
71		25.36
73	72.68	
76	37.69	
77	114.40	

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TABLE C-13. TOTAL COLIFORM BACTERIA AEROSOL CONCENTRATION AT SITES LOCATED <150 m DOWNWIND FROM THE CENTER OF THE AERATION TANKS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
4		0.00
7	2.40	
9	0.00	
11	0.00	
12		0.00
14		0.00
15	0.00	
17	0.00	
17	0.13	
18		0.00
20	0.00	
23		1.30
24		0.60
25	4.30	
25	3.20	
27		0.40
29		0.12
31		0.00
32	0.00	
33		0.14
36	0.59	
37	0.27	
40	0.00	
41		1.99
42	0.41	
43	0.00	
45	15.60	
46		9.46
47		12.86
49	2.17	
50	3.53	
52	37.72	
53		1.09
54		0.72
56		2.41
58	8.35	
61		7.54
64		1.27
65	0.00	
67		13.48
68		6.46
70		1.35
71		16.99
73	3.99	
75	13.77	
76	3.26	
77	24.36	

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TABLE C-14. TOTAL COLIFORM BACTERIA AEROSOL CONCENTRATION AT SITES LOCATED 150 TO 250 m DOWNSTREAM FROM THE CENTER OF THE AERATION PLANTS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
2	0.00	
3		0.60
4		0.00
11	0.00	
12		0.00
14		0.00
14		0.10
15	0.00	
15	0.00	
17	0.00	
18		0.00
20	0.00	
23		0.00
23		0.50
24		0.00
24		0.20
27		0.13
28	0.35	
28	0.42	
28	0.40	
29		0.11
31		0.14
32	0.28	
33		0.00
36	1.28	
37	0.26	
37	0.00	
40	0.00	
40	0.32	
41		1.42
42	0.00	
43	0.14	
45	4.21	
46		0.54
47		2.57
49	0.45	
50	0.36	
50	0.00	
52	13.22	
53		0.40
54		0.48
56		2.49
58	0.00	
59	1.27	
61		0.16
64		0.32
65	0.00	
67		5.26
68		0.15
70		1.05
70		0.18
71		6.42
71		0.00
73	4.81	
75	3.91	
76	0.16	
77	1.61	
77	0.36	

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TABLE C-15. TOTAL COLIFORM BACTERIA AEROSOL CONCENTRATION AT SITES LOCATED >250 m DOWNWIND FROM THE CENTER OF THE AERATION PLANTS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
3		1.60
9	0.00	
11	0.00	
12		0.00
18		0.00
20	0.68	
27		0.00
29		0.12
31		0.00
32	0.71	
33		0.00
36	0.15	
41		0.70
42	0.00	
43	0.00	
45	4.16	
46		0.59
47		1.45
49	3.78	
52	4.49	
53		0.16
54		0.00
56		1.05
58	0.44	
59	0.90	
61		0.00
64		0.55
65	0.16	
67		0.91
68		0.18
73	0.80	
75	0.48	
76	0.00	

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TABLE C-16. TOTAL COLIFORM BACTERIA AEROSOL CONCENTRATION AT SITES LOCATED UPWIND FROM THE CENTER OF THE AERATION PLANTS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
2	0.10	
4		0.00
7	1.20	
9	0.00	
11	0.00	
12		0.00
14		0.00
15	0.00	
17	0.00	
18		0.10
20	0.24	
23		0.00
24		1.10
25	2.50	
27		0.00
28	0.22	
29		0.13
31		0.12
32	0.67	
33		0.00
36	0.15	
37	0.24	
40	0.15	
41		6.19
42	0.12	
43	0.13	
45	0.00	
46		0.00
47		0.90
49	0.00	
50	5.71	
52	0.00	
53		0.15
56		0.00
58	1.48	
59	0.40	
61		0.00
64		0.13
65	0.00	
67		0.00
68		0.00
70		0.00
71		0.54
73	0.00	
75	0.00	
76	0.00	
77	0.00	

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TABLE C-17. FECAL COLIFORM BACTERIA AEROSOL CONCENTRATION AT SITES LOCATED <150 m DOWNWIND FROM THE CENTER OF THE AERATION PLANTS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
4		0.00
7	0.00	
9	0.00	
11	0.00	
12		0.00
14		0.00
15	0.60	
17	0.10	
17	0.30	
18		0.00
20	0.00	
23		1.40
24		2.40
25	0.00	
25	0.00	
27		0.00
29		0.00
31		0.00
32	0.00	
33		0.00
36	0.00	
37	0.00	
40	0.00	
41		0.00
42	0.00	
43	0.00	
45	0.00	
46		2.27
47		0.00
49	0.18	
50	1.01	
52	6.29	
53		0.09
54		0.18
56		0.56
59	47.72	
61		5.45
64		0.54
65	0.00	
67		1.77
68		0.81
70		7.20
71		2.71
73	0.45	
75	3.26	
76	0.09	
77	4.44	

TABLE C-18. FECAL COLIFORM BACTERIA AEROSOL CONCENTRATION AT SITES LOCATED 150 TO 250 m DOWNWIND FROM THE CENTER OF THE AERATION PLANTS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
2	0.00	
3		0.00
4		0.00
11	0.00	
12		0.00
14		0.00
14		0.00
15	0.20	
15	1.60	
17	7.40	
18		0.00
20	0.00	
23		0.90
23		0.00
24		0.40
24		1.10
27		0.00
28	0.00	
28	0.00	
28	0.00	
29		0.00
31		0.00
32	0.00	
33		0.00
36	0.00	
37	0.00	
37	0.00	
40	0.00	
40	0.00	
41		0.00
42	0.00	
43	0.00	
45	0.00	
46		0.00
47		0.08
49	0.00	
50	0.09	
50	0.00	
52	1.81	
53		0.07
54		0.16
56		0.71
58	0.00	
59	0.27	
61		0.08
64		0.48
65	0.08	
67		2.03
68		0.00
70		4.74
70		0.82
71		1.28
71		0.00
73	1.05	
75	0.83	
76	0.00	
77	0.00	
77	0.00	

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TABLE C-19. FECAL COLIFORM BACTERIA AEROSOL CONCENTRATION AT SITES LOCATED >250 m DOWNWIND FROM THE CENTER OF THE AERATION PLANTS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
3		0.00
9	0.00	
11	0.00	
12		0.00
18		0.00
20	0.00	
27		0.00
29		0.00
31		0.00
32	0.00	
33		0.00
36	0.00	
41		0.00
42	0.00	
43	0.00	
45	0.00	
46		0.07
47		0.09
49	0.06	
52	0.16	
53		0.00
54		0.00
56		0.30
58	0.44	
59	0.38	
61		0.00
64		0.34
65	0.24	
67		0.27
68		0.00
73	0.40	
75	0.32	
76	0.00	

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TABLE C-20. FECAL COLIFORM BACTERIA AEROSOL CONCENTRATION AT SITES LOCATED UPWIND FROM THE CENTER OF THE AERATION PLANTS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
2	0.00	
7	0.05	
9	0.00	
11	0.00	
12		0.00
14		0.00
15	0.00	
17	0.10	
18		0.00
20	0.00	
23		0.00
24		0.00
25	0.00	
27		0.00
28	0.00	
29		0.00
31		0.00
32	0.00	
33		0.00
36	0.00	
37	0.00	
40	0.00	
41		0.00
42	0.00	
43	0.06	
45	0.00	
46		0.00
47		0.00
49	0.00	
50	0.08	
52	0.00	
53		0.00
54		0.00
56		0.07
58	0.00	
59	0.00	
61		0.00
64		0.00
65	0.00	
67		0.07
68		0.00
70		0.00
71		0.00
73	0.00	
75	0.07	
76	0.00	
77	0.00	

TABLE C-21. FECAL STREPTOCOCCUS BACTERIA AEROSOL CONCENTRATION AT SITES LOCATED < 150 m DOWNWIND FROM THE CENTER OF THE AERATION PLANTS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
4		0.00
7	0.20	
9	0.00	
11	0.00	
12		0.10
14		0.10
15	0.00	
17	0.10	
17	0.00	
18		0.50
20	0.10	
23		0.00
24		0.00
25	0.10	
25	0.30	
27		0.40
29		1.37
31		0.58
32	0.00	
33		0.00
36	0.06	
37	0.20	
40	0.00	
41		1.91
42	0.00	
43	0.41	
45	0.18	
46		1.32
47		0.50
49	0.27	
50	0.63	
52	1.26	
53		1.36
54		0.09
56		1.12
58	0.00	
59	0.72	
61		1.08
64		0.91
65	0.00	
67		2.81
68		4.44
70		4.44
71		1.43
73	0.18	
75	0.54	
76	0.18	
77	0.83	

TABLE C-22. FECAL STREPTOCOCCUS BACTERIA AEROSOL CONCENTRATION AT SITES LOCATED 150 TO 250 m DOWNWIND FROM THE CENTER OF THE AERATION PLANTS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
2	0.10	
3		0.10
4		0.20
7	0.21	
11	0.00	
12		0.40
14		0.20
14		0.10
15	0.00	
15	0.10	
17	0.20	
18		0.40
20	0.00	
23		0.00
23		0.00
24		0.00
24		0.00
27		0.45
28	0.07	
28	0.20	
28	0.03	
29		0.57
31		1.18
32	0.07	
33		0.00
36	0.13	
37	0.32	
37	0.53	
40	0.00	
40	0.00	
41		8.08
42	0.91	
43	0.14	
45	0.08	
46		0.45
47		1.77
49	0.23	
50	0.09	
50	0.16	
52	0.27	
53		1.14
54		0.72
56		1.78
58	0.00	
59	0.27	
61		0.16
64		0.56
65	0.00	
67		2.41
68		3.53
70		3.08
70		2.63
71		0.96
71		0.79
73	0.53	
75	0.38	
76	0.00	
77	0.16	
77	0.09	

TABLE C-23. FECAL STREPTOCOCCUS BACTERIA AEROSOL CONCENTRATION AT SITES LOCATED >250 m DOWNWIND FROM THE CENTER OF THE AERATION PLANTS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
3		0.20
7	0.80	
9	0.00	
11	0.00	
12		0.20
18		0.30
20	0.00	
27		0.30
29		0.89
31		0.54
32	0.12	
33		0.13
36	0.07	
41		3.58
42	0.00	
43	0.00	
45	0.06	
46		0.52
47		5.16
49	0.32	
52	1.61	
53		0.56
54		0.51
56		0.60
58	3.03	
59	0.68	
61		0.09
64		1.44
65	1.12	
67		1.18
68		3.62
73	0.32	
75	0.00	
76	0.08	

TABLE C-24. FECAL STREPTOCOCCUS BACTERIA AEROSOL CONCENTRATION AT SITES LOCATED UPWIND FROM THE CENTER OF THE AERATION PLANTS

Trial No.	Daytime, cfu/m^3	Nighttime, cfu/m^3
2	0.20	
4		0.00
7	0.25	
9	0.00	
11	0.00	
12		0.30
14		0.10
15	0.00	
17	0.00	
18		0.40
20	0.00	
23		0.00
24		0.00
25	0.00	
27		0.37
28	0.00	
29		2.02
31		0.30
32	0.06	
33		0.59
36	0.37	
37	0.06	
40	0.15	
41		4.05
42	0.48	
43	0.38	
46		0.08
47		0.08
49	0.40	
50	0.98	
52	0.07	
53		0.45
54		0.40
56		1.55
58	0.13	
59	0.07	
61		0.23
64		1.95
65	0.00	
67		0.13
68		1.93
70		2.89
71		1.00
73	0.00	
75	0.07	
76	0.00	
77	0.00	

APPENDIX D. MEDIA AND REAGENTS

	Medium or Reagent	Volume	No. per Site	No. Sites/ Day	Total/ Samp. Day	Storage Time	No.Samp. Days/ Storage Time	Total Preparation
TABCP(S)	TSA+C+O	70 ml/plate	8 plates	4	32 +2 plates	2 wks	4	136 plates
	70% ETOH	-	-	-	50 ml	-	-	50 ml
TABCP(A)	TSA-C+O	27 ml/plate	24 plates	4	96 + 6 plates	2 wks	4	408 plates
	70% ETOH		-	-	50 ml	-	-	50 ml
Samp.Scheme A TPC	0.25% TSB	120 ml/flask	1 flask	4	4 + 1 flasks	3 mos.	12	60 flasks
	TGYA	15 ml/plate	6 plates(90 ml)	4	360 + 40 ml	3 mos.	12	12 x 500ml flasks
	PBW	9 ml/tube	5 tubes	4	20 tubes	3 mos	12	240 tubes
TC	m-Endo Broth	2 ml/plate	2-6 plates	4	8-24 + 6 plates	96 hr	1	75 ml
	E. aerogenes	10 ml tube	1 tube	4	1 tube	1 day	1	1 tube
	TSA agar slants	10 ml/tube	10 tubes	4	40 tubes	3 mos	12	480 tubes
	PBW	500 ml/flask	0.5 flasks	4	2 flasks	3 mos	12	24 flasks
FC	m-FC broth	2 ml/plate	2-6 plates	4	8-24 + 6 plates	96 hr	1	75 ml
	E. coli	10 ml/tube	1 tube	4	1 tube	1 day	1	75 ml
	Rosolic acid, 1%	-	-	-	-	2 wks	4	5 ml
	PBW	500 ml/flask	0.5 flasks	4	2 flasks	3 mos	12	24 flasks
FS	KF Strep. agar	5 ml/plate	2-6 plates	4	8-24 + 6 plates	4 wks	8	240 plates
	S. faecalis	10 ml/tube	1 tube	4	1 tube	1 day	1	1 tube
	TTC solution (1%)	1 ml/100 ml	-	-	-	-	-	12 ml
	PBW	500 ml/flask	0.5 flasks	4	2 flasks	3 mos	12	24 flasks
KB	API strips	-	10 strips	4	40 strips	3 mos	12	480 strips
	K. pneumoniae	10 ml/tube	1 tube	4	1 tube	1 day	1	1 tube
	TSA agar slants	10 ml/tube	10 tubes	4	40 tubes	3 mos	12	480 tubes
	0.2% ascorbic acid	add 25 ml H_2O	10 tests	4	40 tests	28 days	8	25 ml
	Oxidase reagent	5 ml/bottle	10 drops	4	1 bottle	1 week	1	1 tube
	Pseudomonas aeruginosa	10 ml/tube	1 tube	4	1 tube	1 day	1	1 tube
	0.85% saline	5 ml/tube 10 tubes	4	40 tubes		3 mos	12	480 tubes
	Sterile mineral 0.1	60 ml/bottle	5 ml	4	20 ml	3 mos	12	240 ml
	Kovac's reagent	15 ml/bottle	10 drops	4	1 ml	3 mos	12	12 ml
	40% potassium hydroxide	30 ml/bottle	10 drops	4	1 ml	3 mos	12	12 ml
	6% Alpha naphthol	12 ml/bottle	10 drops	4	1 ml	2 wks	4	4 ml
	10% ferric chloride	30 ml	12 drops	4	1 ml	3 mos	12	12 ml

APPENDIX D. (CONTINUED)

	Medium or Reagent	Volume	No. per Site	No. Sites/ Day	Total/ Samp. Day	Storage Time	No. Samp. Days/ Storage Time	Total Preparation
Samp. Scheme B_c CP	0.25% PAB	120/flask	1 flask	4	4 + 1 flasks	3 mos	6	30 flasks
	1.75 x PAB tubes	3 ml/tube	40 tubes	4	160 tubes	3 mos	6	960 tubes
	PABA (.7% agar) tubes	2.5 ml/tube	8 tubes	4	32 tubes	3 mos	6	192 tubes
	PABA plates	20 ml/plate	8 plates	4	32 plates	2 wks	2	64 plates
	E. coli C3000 host	4 hr culture	4 ml	4	16 ml	1 day	1	50 ml
	PAB tubes	50 ml/flask	1 flask	4	1 flask	3 mos	6	6 flasks
	MS2 phage	10 ml/tube	1 tube	4	1 tube	2 wks	2	2 tubes
Samp. Scheme B_s	0.5% DSE	120 ml/flask	1 flask	4	4 + 1 flasks	2 wks	2	10 flasks
	1.5 x DSE	3 ml/tube	40 tubes	4	160 tubes	2 wks	2	320 tubes
	S. enteriditis	10 ml/tube	1 tube	4	1 tube	1 day	1	1 tube
	XLD plates	20 ml/4-place plate	10 plates	4	40 plates	2 wks	2	80 plates
Samp. Scheme C AV processing	0.25% NB in HBSS	50 ml/bottle	2 bottles	2	4 + 1 bottles	3 mos	6	30 bottles
	Clorox solution	50 ml/bottle	-	-	1 bottle	3 mos	6	1 bottle
	Sodium thiosulfate sol.	50 ml/bottle	-	-	1 bottle	3 mos	6	1 bottle
	HIFCS	5 ml/bottle	-	-	1 bottle	3 mos	6	1 bottle
AV Assay(portion A)	BGM flasks, 75 cm^2	20 ml media/flask	6 flasks	2	12 flasks	3 days	1	12 flasks
	flasks 25 cm^2	6 ml media/flask	4 flasks	2	4 flasks	3 days	1	4 flasks
	tubes	1 ml media/tube	20 tubes	2	40 tubes	3 days	1	40 tubes
	HBSS solution	500 ml/bottle	350 ml	2	700 ml	3 mos	6	5 liters
	Poliovirus type 1	5 ml/bottle	350 ml	2	700 ml	3 mos	6	30 ml
	MEM	20 ml or 10 ml/flask	350 ml	2	700 ml	3 mos	6	5 liters
	HIFCS	20 ml/1 MEM	-	-	-	3 mos	6	100 ml
	HEPES buffer	25 M/1 MEM	-	-	-	3 mos	6	
	Gentamicin	50,000 μg/1 MEM	-	-	-	3 mos	6	
	Fungizone	2500 μg/1 MEM	-	-	-	3 mos	6	
	Glutamine					3 mos	6	
Portion B If plaque assay to Portion A list	neutral red (1.1000)	4 ml/1 MEM	-	-	-	3 mos	6	20 ml
	$MgCl_2 \cdot 6H_2O$(50%)	10 ml/1 MEM						50 ml
	Difco-Bacto Agar	15 g/1 MEM						75 g
	HBSS with H,P,S, & F	2 ml/tube	20 tubes	2	40 tubes	3 mos	6	240 tubes
	Lim-Benyesh-Melnick pooled antisera							

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